CORAL REEF CHANNELS

RECONNAISSANCE REPORT

HONI SOIT QUI MAL Y PENSE

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ROYAL N.Z. ENGINEERS

TOKELAU ISLANDS

1985

25

25 Engineer Support Squadron

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

FOR: Chief Engineer

BY: Lieutenant A.M. Skinner, RNZE

AT: 0800 hours **ON:** 10 May 85

References:

A. NZ Def Army 3304/1/CE LBC/KQE of 070337Z Feb 85

B. Terms of Reference for Tokelau Islands Reconnaissance, Chief Engineers Office 3304/1/CE dated 15 Feb 85

C. Ministry of Foreign Affairs 118/13/109/1 dated 20 Feb 85

D. Notes of a Meeting with Mr Gotfred Shuma dated 19 Mar 85

E. Report on Reef Blasting at Fakaofo Island Tokelau Group 14 May - 24 Sep 63 by Lieutenant D.W.S. Maloney, RNZE

F. Report on Further Channel Development at Fakaofo during mid 1964 by Warrant Officer Class Two D.H. Roberts, RNZE

Disbribution:

Army GS (Attn: CE)	(3)
File	(2)
Spare	(2)

For Information:

Spt Comd (Attn: SO1 Ops)	(2)
Ministry of Foreign Affairs (Attn: Ms D. Almao)	(2)
SME (Attn: RNZE Corps Memorial Clerk)	(1)

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ORDER FOR THE REPORT

Origin

1. Quarter Master, 25 Engineer Support Squadron, received a Tele Printer Message Order to conduct a reconnaissance to Tokelau Islands. The date/time group of the Tele Printer Message was 070337Z Feb 85 and the reconnaissance was to be carried out during the period 23 February - 24 March 1985.

Aim of Report

2. The aim of the report is to determine the work required to improve the existing reef channels on Tokelau Islands to the standards laid down in the specifications. See Annexes A and B.

Specifications (See Annex B)

3. As detailed:

   a. deepening and widening to 7 - 8 m, the reef channel at Atafu;

   b. deepening and widening the Nukumonu reef channel; and

   c. removing rubble from the existing channel at Fakaofo (Fale) and, either:

      (1) realigning, widening by 7 - 8 m and deepening it, or

      (2) developing the nearby natural channel.

4. Annex A requests an opinion to be made on the Nukunonu channel, which was reported to be of satisfactory width but may require deepending at the shore.

Other Considerations

5. The final designs for each channel and the appropriate improvements were to be done by a Ministry of Works and Development Construction Engineer.

6. The following guidance was given:

/a. any local

a. any local knowledge pertaining to the reef channels and sea action on and around the reef was to be sought; and

b. the wishes of the Council of Elders' must be respected.

Composition of Reconnaissance Team

7. The following personnel were detailed to conduct the reconnaissance:

a. Team Leader. Mr B. Prendergast, Ministry of Works and Development (Airfield reconnaissance).

b. Mr P. Asher, Ministry of Works and Development (advice on channels and proposed airfield sites).

c. Mr W. Hill, Ministry of Works and Development Environmentalist (Aifrield reconnaissance).

d. Mr P. Lawless, Commission for the Environment (Airfield reconnaissance).

e. Lieutenant A.M. Skinner, RNZE (Channel reconnaissance).

f. Chief Petty Officer J. Kearney, RNZN (Ship wreck reconnaissance).

8. The above were to depart Tokelau 2 March 1985 except sub-paras d., and e., who were to depart Tokelau 16 March 1985.

Completion

9. The report is to be handed to Chief Engineer, Chief Engineer's Branch, Army General Staff on 13 May 1985.

ENGINEER RECONNAISSANCE REPORT

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TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

INTRODUCTION

General Outline of Report

1. The report has been written to assess the work required to improve three reef channels. The Introduction describes life on Tokelau. The remainder of the report is divided into two parts:

a. Part I: Summary; and

b. Part II: Main Body.

Part II is then divided into Section A, Section B and Section C to enable an individual study of each channel.

Tokelau

2. Geography. Tokelau is a New Zealand dependancy in the South Pacific Ocean, comprising three coral atolls. It is situated between 172°30'W and 171°W, and 8°30'S and 9°30'S, approximately 500 km north of Western Samoa and 1,000 km east of Tuvalu. Tokelau is of volcanic origin and the remaining circular coral reefs enclose a deep lagoon. The three atolls are Atafu (northern most), Nukunonu and Fakaofo in the south, 100 km and 50 km apart respectively. The average width of the reef is 600 m and this descends steeply into very deep water on the seaward side. The reef is dotted with numerous islets rising to a maximum elevation of 4.0 m and up to 6.0 km in length. All islets are caused by wave action building up loose coral rock towards the lagoon side of the reef. This leaves an expanse of up to 400 m of reef from the islet to the open sea. There is no access for large shipping into the lagoons and depressions in the reef top (natural channels) are used by the locals for access across the reef for small fishing boats. These natural channels provide drainage for reef top water and lagoon spillage, thus maintaining a sensitive equilibrium between the lagoon water and the ocean.

3. Economy. Tokelau does not have an established export industry. The small quantities of Copra exported to Western Samoa by individual families, the sale of handicrafts and stamps, all provide a small amount of finance to each village. Financial assistance is received from New Zealand and is essential for the Tokelau population.

4. Population. Figures from the latest census of 19 October 1984 are as follows:

/Atafu

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/Atafu

	Male	Female	Total
Atafu	297	292	589
Nukunonu	205	211	416
Fakaofo	315	307	622
Total	817	810	1627

5. Climate. The mean average temperature is 28°C. February is the coolest month and May the warmest. The daily rainfall, of up to 80 mm, is heavy but irregular.

6. Administration. The administration of Tokelau is controlled by a Ministry of Foreign Affairs representative, the Official Secretary, who works for the Office for Tokelau Affairs in Apia, Western Samoa. Currently the appointment is held by Mr A.H. Macey and the Chief Administration Officer is Mr Kasimilo Perez. Other official appointments held on Tokelau are as follows:

a. Atafu.

(1) Faipule - Mr Amusia Perez

(2) Pulenuku - Mr Lokeni Malaki

(3) Administration Officer - Mr Maka Toloa

(4) Doctor - Dr Semo Koro

(5) School Principal - Mr Tenise Atoni

(6) Pastor - Rev Iosua Faamaoni

(7) President of the Aumaga - Mr Tiu Kalolo

b. Nukunonu.

(1) Faipule - Mr Tauanau Kele

(2) Pulenuku - Mr Fatia Perez

(3) Administration Officer - Mr Henry Joseph

(4) Doctor - Dr Tekie Iosefo

(5) School Principal - Mr Luciano Perez

(6) Catechist - Rev Niko Tuia

(7) President of the Aumaga - Mr Fatia Perez

/c. Fakaofo.

c. Fakaofo.

(1) Faipule - Mr Faafoi Sakaria

(2) Pulenuku - Mr Tu Matini

(3) Administration Officer - Mr Pio Tuia

(4) Doctor - Dr Elekana Sakaria

(5) School Principal - Mr Sosene Galo

(6) Catechist - Mr Pio Tuia

(7) Pastor - Rev Tui Sopoaga

(8) President of the Aumaga - Mr Peleni Apolo

7. Language. Tokelauan is the principle language and is used for all official and unofficial correspondence, both written and oral. English is spoken well by all Administration Officers, Doctors and Principals, the younger population can, generally, understand English.

8. Local Government. Each atoll has a Council of Elders (Taupulega), which acts as the Government and decision making body. It is presided over by the Faipule and his Deputy is the Pulenuku. Generally, the Taupulega consists of the village elders and the heads of each family group. The Faipule has the role of Island Chief and the Pulenuku is the 'Mayor' of the village.

9. Work Force. Two work forces exist on each atoll; Public Works (about 12 men) overseen by Director of Works in Office for Tokelau Affairs, Apia and the Aumaga. All men over the age of 18 years automatically become members of the Aumaga and are employed by the President of Aumaga on local tasks. These are generally, on village improvements which are directed by Pulenuku. Generally, the men work two weeks on, two weeks off, and are paid approximately NZ$10.00 per week.

10. Food. Tokelau's food resources are extremely limited due to the lack of top soil. The food that is produced on the atolls is coconuts, breadfruit, Lu (a broad leafed shrub), bananas, pawpaw and pandanas (which is only chewed for its flavour). Fish around Tokelau is extremely abundant. Pigs and chickens are kept by the villagers but are only eaten on special occasions. A small amount of tinned food, rice, sugar and flour, is brought and used to supplement the diet.

11. Stores Supply to Tokelau. The only transport to and from Tokelau is aboard a cargo ship, the "MV AVONDALE", which runs from Apia to Tokelau return once every six weeks approximately. This is the only form of resupply available.

12. Medical. A modern hospital is established on each atoll and has the capacity for minor surgery and theatre operations. A qualified Doctor and two Registered Nurses are employed at each

/hospital.

hospital. The staff is supplemented by approximately six enrolled nurses. The only dentist in Tokelau is on Fakaofo.

13. <u>Religion.</u> Religion plays a major role in village life. Each atoll has a large concrete church built during the late 1800s/early 1900s by Anglican or Roman Catholic missionaries. Atafu is totally Protestant, Nukunonu is all Roman Catholic and Fakaofo has both denominations, each with a separate church. Sunday is always observed as a reverent day and no work is allowed to be done (including cooking). Everyone is expected to attend a church service at least once during the day.

14. <u>Education.</u> Schooling is provided on each atoll and is compulsory for children up to 14 years old (4th form). A few children then complete 5th form overseas, mainly in New Zealand. English is taught at each school as a compulsory language.

15. <u>Postal.</u> All mail and written correspondence is transported by the cargo ship.

16. <u>Recreation.</u> Tokelau provides for excellent diving, fishing and boating. The Aumaga play a "form" of cricket in the village centre every Thursday afternoon. Tennis and volleyball are played a lot in the school grounds. The women play a lot of cards and dominoes.

17. <u>Communications.</u> A poor radio telephone system is employed between each atoll and back to Apia. This produces a very distorted reception and has caused some confustion in the past. A modern telephone system is about to be installed.

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

PART I: SUMMARY

Aim

1. The aim of this Report is to determine the engineer works required to improve three existing reef channels on Tokelau Islands.

Works Required for Improvements

2. The following is a summary of the work necessary to improve the channels:

a. Atafu. Widen LHS and RHS of the channel at the entrance and deepen the channel to achieve a depth 1.2 m at Low Tide. This involves approximately 500 m^3 of fines to be removed by local labour and approximately 900 m^3 by drilling and blasting All deepending required involves the removal of fines.

b. Nukunonu. Deepening of channel to achieve a minimum depth of 1.2 m at Low Tide. This involves the removal of approximately 1450 m^3 of fines by local labour. There is no requirement for Army tasking at Nukunonu.

c. Fakaofo. Widen the channel on the LHS and achieve a depth of 1.2 m at Low Tide. This involves the removal of approximately 1000 m^3 of fines by local labour and approximately 1500 m^3 of rock by drilling and blasting. All deepening required involves the removal of fines only.

Time and Space

3. All calculations for the time required to complete the tasks is based on the time available for work to be conducted on the reef. This is during low tide. The work period is five hours every 12 1/2 hour tide cycle and is from 2 1/2 hours before Low Tide to 2 1/2 hours after Low Tide. The following is a summary of total time required to complete the improvements on the reef channels at Atafu and Fakaofo (see TIME AND SPACE):

a. Drilling. Atafu - 7 days
Fakaofo - 11.5 days

b. Blasting. Atafu - 29 days
Fakaofo - 47 days

/c. Contingencies.

c. Contingencies. Atafu - 23 days
Fakaofo - 34.5 days

d. Travelling Time/Stores Handling. 22 Days.

e. Total Time Required to Complete Work in Tokelau. 154 Days.

f. Total Time Out of Country. 174 Days, approximately 5 1/2 months.

Finance

4. The following is a summary of costs expected to be incurred:

a. Explosives (see Annex Q) - $15545.52.

b. POL (see Annex R) - $10191.94.

Machinery

5. The only machinery required is involved in drilling and blasting. (LM-100 airtrack drill and a 375 CFM compressor) (see Annex M).

Manpower

6. The task requires a small team of highly trained personnel. The manning is at Annex P and consists of one x officer and nine x ORs, including one x vehicle mechanic and one x cook.

Stores

7. Sufficient stores are required to be taken to Tokelau to enable the team to remain in location and work totally self sufficient (see Annex O).

Accommodation and Rations

8. While in Tokelau, the team will be accommodated in European style 'Guest Houses'. A cook has been included as a member of the team and will provide meals from stocks of fresh/tinned food taken to Tokelau and that locally obtained. It is suggested that a commercial pattern refrigerator approximately 2 m^3 capacity c/w 6.5 KVA generator are also taken.

Reef Channels

9. The three reef channels reconnoitred have been summarised later in the Report (see blue pages - Atafu, pink pages - Nukunonu and yellow pages - Fakaofo).

Local Resources

10. Local labour will be responsible for the removal of all fines and infill of the channels prior to the team commencing any tasks. The only local resources that can be relied upon for use are:

a. local labour; and

b. local food, when necessary or desired.

Conclusions

11. The following are conclusions:

a. The Atafu reef channel requires widening on both LHS and RHS at the channel entrance.

b. The channel at Nukunonu requires deepening, but this involves the removal of fines only and is not considered an Army task.

c. The Fakaofo channel, at Fale, requires widening on LHS.

d. Atafu and Fakaofo channels also require the removal of fines from the channel bottom, this is not considered an Army task.

Recommendations

12. It is recommended that a RNZE team deploy to Tokelau for an extended period (5 1/2 months) to undertake the improvements required at Atafu and Fakaofo as stated in paragraph 11. The acceptance of the task should only be given on the understanding that the removal of fines is not an Army responsibility.

10 May 1985

(A.M. SKINNER)
Lieutenant
Quarter Master

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

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ON TOKELAU ISLANDS

PART II: MAIN BODY

General

1. The reconnaissance party left New Zealand on 23 February 1985. The party consisted of personnel from three Government Departments. These were:

a. Ministry of Defence, (Army and Navy);

b. Ministry of Works and Development; and

c. Commission for the Environment.

2. The 'Terms of Reference' (see Annex A), proved to be of great assistance in detailing specific responsibilities and enabled a sound working relationship to be established amongst the members of the party. It did, however, have to be used from time to time to pursuade reluctant members of the team to impart their knowledge for the benefit of others.

Timetable of Events

3.

Date	Activity	Remarks
(a)	(b)	(c)
23 February 1985	Auckland - Apia	Arrive 22 February 1985, Western Samoan time
23 February 1985	Apia - Tokelau	MV Avondale
24 February 1985	En-route to Tokelau	MV Avondale
25 February 1985	Airfield reconnaissance Fakaofo	Arrive 250530
26 February 1985	Airfield reconnaissance Fakaofo	Depart 261730
27 February 1985	Airfield reconnaissance Nukunonu	Arrive 270600
28 February 1985	Channel reconnaissance Nukunonu	Depart 281900

/1 March 1985

Date	Activity	Remarks
(a)	(b)	(c)
1 March 1985	Airfield reconnaissance Atafu	Arrive 010630
2 March 1985	Airfield reconnaissance Atafu	MWD and Commission for Environment personnel depart 0201730
3-11 March 1985	Channel reconnaissance Atafu	Depart 111700
12 March 1985	Enroute to Fakaofo	Arrive 120500
13-15 March 1985	Channel reconnaissance Fakaofo	Depart 151900
15-18 March 1985	Enroute Apia	Arrive 181200
18-22 March 1985	Apia	Depart 221900
23 March 1985	Auckland	Arrive 232300

Channel Reconnaissance

4. Outline of Problems. As described in paragraph 1., of the Introduction, the Tokelau atolls descend approximately 600 fathoms to the ocean floor. The mooring of any ocean going vessel is impossible at Tokelau and, as in the case of the supply ship MV AVONDALE, the ship drifts approximately 500 m off shore whilst loading and unlaoding cargo. The transport of stores/passengers from the ship to land is by the use of large aluminium boats (see Annex F). The outboard motors are grossly under powered for the loads carried and generally the boats are 'carried by the waves', rather than steered into the channels. The edge of the coral reef is extremely treacherous for boating due to the waves building up and then breaking across the reef. On all three atolls, the channels have been built utilising existing natural channel entrances.

a. Atafu. The channel at Atafu is correctly alligned to the breaking waves but is too narrow at the entrance for safe negotiation. During the reconnaissance, boats were overturned at the entrance with stores and equipment lost. Atafu has an excellent concrete wharf at the end of the channel and enables efficient handling of cargo on and off the Island.

b. Nukunonu. The Nukunonu channel is a very wide channel correctly aligned at 90° to the waves. It is a natural channel that has had minimal work done on improving it. It is very rare that any

/boating

boating accidents occur here due to the relatively calm nature of the sea and waves. It does have a problem of silting up with coral sand from the beach due to wave action.

c. Fakaofo. The channel at Fale on Fakaofo is the most developed channel of the three. It has an easily accessible concrete wharf built at the same level as the surrounding reef, concrete side walls and a newly constructed 2.0 m high sea wall. Its major failing is that it is incorrectly aligned to the breaking waves. The Fale channel was purposely aligned at an angle to the waves so that there would be no risk of waves surging the length of the channel unimpeded. This proved to be incorrect. It was found that breaking waves loose 75% of their momentum after travelling 100 m across the reef. Numerous boating accidents occur at Fale as the boats attempt to 'dog leg' in the surf at the entrance of the channel (see Annex K).

Previous Survey

5. An accurate survey has never been conducted on any of the reef channels at Tokelau. However, a survey was undertaken in February and May 1976 by Mr P. Benfell. He recorded his results, on rough sketches. These are at Annex D. These drawings show that, on an average, there has been an increase of 0.5 m in channel bottom centre line height. Undoubtedly, the fines build up far quicker than 0.5 m/9 year period, but it would suggest that the infill of each channel is relatively slow. Periodic maintenance has not been conducted on any of the channels during the past three years.

Design Parametres

6. The specific designs for each channel are laid down in the respective Sections to Part II for each channel (see Section A - Atafu, Section B - Nukunonu, Section C - Fakaofo). Annexes A and B stress the requirement to determine whether any of the channels need to be deepened. In consultation with local Elders, Mr P. Asher and Mr B. Prendergast, it was decided to establish a constant for the minimum depth of any channel. The constant is as follows:

Low Tide Level - 1.0 m = channel bottom depth. A further depth of 0.2 m was added for contingencies such as in fill of fines and wave swell and surge. Therefore constant is:

Minimum Channel bottom depth = Low Tide Level - 1.2 m = Spring Low Tide Level - 1.0 m

(it was found that at all three channels, the difference in height between LT and SLT = 0.2m).

/All drawings

All drawings (at Annexes I, J and K), and the calculation of volumes of material to be removed have been completed using this constant. It will be seen that any deepending required involves the removal of fines only.

Nature of Coral Reef

7. Coral is a living organism and as such dies. This dead coral forms a detritus layer of soft, broken, and in cases, powdery material. It varies from 0.3 - 1.0 m below the top of the reef and is between 0.3 - 0.75 m in depth (see Annex E). This layer may cause problems when drilling and blasting.

'MV Avondale'

8. The 'MV Avondale' is a 33 year old cargo ship approximately 100 m in legnth and about a 2,200 ton displacement. It is chartered by the Office for Tokelau Affairs for approximately 10 journeys a year from Apia to Tokelau return. At Annex G is the 1985 schedule including passenger fares. The owner company is WARNER PACIFIC SHIPPING LTD. The ship is registered in Tonga and has an entirely Tongan crew. The ship has a large cargo capacity and is licenced to carry explosives and inflammable cargo. Although the life saving equipment is sufficient for 120 passengers at times up to 250 are taken aboard as "deck cargo", (this often means life boats are taken off to make more room for passengers). The length of journey from Apia to Tokelau is 36 hours at seven knots.

Ship to Shore Transport

9. As mentioned in paragraph 4., the locals use aluminium boats with small outboard motors for the transportation of stores, personnel and live stock to and from the ship (see Annex F). Typical loads, for example, are:

a. 24 x people c/w hand luggage/suit cases;

b. 12 x people and 20 x pigs;

c. 10 x 44 gallon drums of fuel;

d. 30 x bags of cement and 12 x bags of flour.

10. The average distance from the reef edge to the ship drifing at sea is 500 m.

Surveying

11. Reconnaissance Team. The reconnaissance team that conducted the surveying of the reef channels was:

a. Observer/Booker. Lieutenant A.M. Skinner, RNZE.

/b. Staffman.

b. Staffman. Chief Petty Officer J. Kearney, RNZN.

c. Chainman. Matulino (local from Nukunonu).

12. Survey Equipment Used. The survey equipment used throughout the reconnaissance was:

a. Wild NK-2 level, c/w tripod;

b. 4 m metric staff, 2 x extensions;

c. 30 m tape;

d. 100 m tape; and

e. compass prismatic.

All equipment used performed well, although the staff proved to be heavy, clumsy and cumbersome in these conditions. Problems with serviceability due to constant exposure to salt water, increased as the job progressed.

13. Survey Grid. At each channel a datum was established and reduced to RL 100.00. Using the datum, a Survey Control Line was established approximately parallel to the channel. Readings were taken at 10 m intervals and given a letter. These points in turn became the control points for the cross-sectional survey across each channel (see Annexes I, J and K). It was intended to place permanent survey marks in the coral using plastic discs and bridging spikes for future reference, however, the coral was found to be too hard and only bent the bridging spikes when hammered.

Work Problems

14. Problems did occur from time to time when conflicting views were expressed by members of the reconnaissance team with regards to degree of detail and accuracy of the survey work.

15. Short manning for this task was overcome when it was discovered that a man on Nukunonu, Matulino, was a qualified surveyor, having spent 12 months in Fiji training. He was of great assistance and also found the surveying practice of benefit. Tokelau does not have any survey equipment.

Natural Channels

16. Natural channels occur on the reef as slight depressions in the reef top. These are used by the locals as an expedient access, when necessary, across the reef, but can not be relied upon in all weathers. The natural channels enable an equilibrium to exist between the lagoon water and the sea water. The natural channels provide an 'overflow' for the lagoon and help drain surface water from the reef.

/17. The Elders

17. The Elders of Atafu and Fakaofo are eager to ensure that the natural channels do not get disturbed or altered in any way.

Accuracy of Survey

18. The survey was conducted as accurately as possible. Not all of the cross-sections were able to be surveyed, but were measured instead. This was due to the swell and surge of waves across the reef, thus causing the level to become unsteady. The cross-sections that were unable to be surveyed are detailed in Sections A, B and C to Part II.

Infill of Fines

19. The depth of fines infill in each channel could not be determined accurately, however, local knowledge suggests that it is a minimum of 1.2 m deep. An accurate record has not been kept of changes in channel bottom depth. Therefore no information is available to suggest the rate at which the channels are filling with fines. This is due to the lack of an accurate survey ever having been done.

20. The local people have a very slack attitude towards the channels and subsequently do not conduct any form of routine maintenance. Periodic routine maintenance would include the removal of fines and obstructions. Each channel has been used as a convenient disposal source for all sorts of rubbish. The type of refuse found in the channels is as follows:

a. numerous coconut shells;

b. iron reinforcing rods;

c. fishing nets;

d. cooking pots; and

e. even the frame of an old bike (at Atafu).

Work Periods

21. At both Atafu and Fakaofo, the only period when the reef is accessible for any form of work is for 2 1/2 hours before Low Tide to 2 1/2 hours after Low Tide, therefore work period is five hours/12 hour tide cycle.

Previous Work Undertaken

22. When previous blasting work has been undertaken at any of the channels, removal of rubble has proved to be no difficulty. Large boulders have been either:

a. man handled onto the reef top and used for reclaimation; or

/b. rolled off

b. rolled off the edge of the reef into deep water.

During the 1963 construction of the Fakaofo channel, two sea walls, 2.0 m high x 3.0 m wide and 100 m long, were constructed from the rubble. All man han handled into place. These walls have since disappeared and been used for reclaimation around the island.

23. An air winch-drag line was in use at Fakaofo approximately 10 years ago for the dredging of the channel during further construction and proved to be very efficient. It has since disappeared without any knowledge of its whereabouts. Annex H makes comment of the advantages of employing this type of equipment.

Channel Revettment

24. The concrete produced on Tokelau by local labour consists of New Zealand cement (generally PORTLAND) and coral sand (due to the impracticalities of getting builders mix ashore). This concrete proves to be of mediocre quality and weathers relatively quickley when constantly subjected to salt water. The locals believe that each channel should be revetted with concrete side walls to stop the gradual infilling of the channels with kilikili. This is totally unnecessary due to the assumed slow rate of infill. None of the channels require any form of retaining walls to stabilise the sides. At Fakaofo, where concrete revettment/ retaining walls were constructed in 1963, the result of subsequent sea action has been that the concrete walls are being undermixed and, in places, have collapsed into the channel. The natural coral channel sides have proved to be very stable and resistant to erosion.

Local Labour

25. Local labour on Tokelau is readily available through the Aumaga. When considering the removal of fines in the channels to achieve the desired minimum depth, the Official Secretary (Mr A.H. Macey) was approached with reference to the locals undertaking this task. Mr Macey said that he is prepared to direct the locals to clean the channels of fines and also ensure that the respective Aumaga establish a programme of routine maintenance. He also agrees that because the locals believe all work associated with the reef channels is not their responsibility but is the task of foreign aid teams such as the Army, the channels should be cleaned out prior to any aid work commencing. The report has been written on the understanding that the removal of fines is not an Army responsibility. Nukunonu Reef Channel is no longer considered a potential Army task because it involves the removal of fines and infill only. Drawings and calculations have been done on Nukunonu for the benefit of Ministry of Foreign Affairs overseeing the local labour.

Local Attitude Towards Offered Assistance

26. The local people, particularly the Elders who are part

/of the

of the Taupulaga, decide amongst themselves:

a. the employment of any offered aid or assistance; and

b. the improvements necessary or tasking required.

In the past, this attitude has caused problems for the aid teams, particularly when the opinions and wishes of the locals are not feasible nor the best solution for that specific problem. They believe that what they desire to have done is, in fact, what is required to overcome the problem. This has often proved to be incorrect. However, if the solution to the problem recommends work that differs from that which the locals believe is required, they will not agree to that work being done.

Ministry of Works and Development Design

27. As detailed in Annex A, the Ministry of Works and Development were to submit a confirmed and recommended design for improvements required for each reef channel. This has not been received and, subsequently, the report has been written without this guidance.

Overview

28. The work required to achieve the necessary results will be awkward and perhaps frustrating. The reef surface is extremely slippery and requires two persons to support each other, arm-in-arm, when moving by foot from place to place. The efficiency of borehole drilling will be a major factor in determining the length of the task. It was hoped during the reconnaissance, to do a test drill and blow of the coral, but the necessary equipment was unable to be taken to Tokelau.

29. In the report by Lieutenant D.W.S. Maloney, it states that the drilling of boreholes on the reef edge was extremely slow and tedious due to:

a. the inefficient production of drilling with hand drifters; and

b. men working in the surf zone and on a slippery surface

On the occasions that large waves broke on the reef, the men were forced to hang on to each other, letting go of all their tools, while the force of the wave dissipated. This proved to be extremely dangerous and inefficient.

Drilling Pattern

30. The drilling patterns used by Lieutenant Maloney, during the construction of Fale (Fakaofo) channel varied as sub-surface coral conditions altered. The hand drifters proved to be very

/inflexible

inflexible because they could not have the speed of rotation adjusted independant to the drilling force (they do not have independant-rotation). Subsequently, a lot of drill jamming and braking of steels occurred.

Lighting for Night Work

31. Whilst researching the possibility of of night work on the reef, no company was found that produced the desired power generation and lighting equipment suitable for the type of task proposed at Tokelau. The considerations were:

a. distance of the work area to the closest possible site of generator on reef (approximately 50 m);

b. generator unable to be floated on a boat due to breaking waves;

c. reticulation of power from generator to task site above water; and

d. anchorage of lights and tripods on coral in wave surge.

Selection of Drilling Equipment

32. Ingersol-Rand was the only rock drilling company contacted with reference to the supply of an air track drill and compressor for the task at Tokelau. This was done on advice from the Ministry of Foreign Affairs, and is the reason that no other products from any other companies are considered.

ADDITIONAL INFORMATION

Transportation of Drilling Equipment

33. There may be a requirement to construct a raft from local resources to transport drilling equipment from the ship to the shore.

Power

34. Each atoll has a 26 KVA diesel generator. This produces more than enough power in the Village and is in operation daily during the hours of 1900 - 2300. Night work was considered as optional but was disregarded. This was due to problems that would arise in supplying power to the edge of the reef, for sufficient lighting to enable work to continue.

Finances

35. Allowances. The allowance advance provided for the Ministry of Defence personnel was initially issued through the Ministry of Defence. As it turned out, the

advance was under estimated due to inter-departmental differences in terminology. To date, the allowances have still not been finalised.

Payment of Locals

36. As mentioned in paragraph 25, the Office for Tokelau Affairs is in favour of the locals clearing fines from channels and providing a manual labour workforce to assist any aid project team. Prior to the employment of any local labour, an hourly rate of pay must be established by the Tokelau Administration and money made available for expenditure as payment for workers. This form of payment would also be required if casual female labour is provided for employment in 'pot walloping' type tasks.

Food

37. It became obvious from the locals' way of life, lethargy and ability to sleep for large portions of the day, that the local food available lacks any real energy providing substance. Whilst surveying, it was found that the New Zealanders could withstand longer periods of work and more time in direct sun light. The Tokelau people live a subsistence lifestyle, working and eating only sufficiently enough to stay alive. The locals can work extremely hard for short periods of time, for example:

a. climbing a coconut tree and cutting off nuts, or

b. unloading boats.

The food proved to be relatively tasteless and very monotonous, though more than enough was always provided.

Medical

38. Although each atoll has a modern hospital and resident Doctor, it would be advisable to take a comprehensive medical kit. Medical dissorders encountered during the reconnaissance were:

a. numerous coral cuts;

b. headaches, from heat and glare;

c. 'coconut bum' continuous bowel motion due to excessive consumption of coconuts;

d. sunburn;

e. shaving rash; and

f. minor cuts (non-coral).

39. It was found that any open wound took an extremely long time to heal. This was due to:

a. the damp humid weather; and

b. flies, which swarm around uncovered wounds.

Gifts

40. There is a requirement for any aid team to go to Tokelau with sufficient ornaments and gifts to give to the Elders, Administration and people. This will save certain embarrassment when, undoubtedly, the locals with their excessive generosity, will give away their handcrafts to the aid team. It is suggested that the gifts taken to Tokelau have an association with the military. Gifts presented to the locals during the reconnaissance included Squadron plaques and Corps badges mounted on native timber ornaments. These were keenly accepted and appreciated.

Manning

41. Due to:

a. the type of task;

b. working conditions;

c. period away from home; and

d. at times, frustrating pace of life,

the personnel required for the task must be carefully selected to ensure a compatible team is established. These personnel should be conversant with modern blasting and quarrying techniques including the use of delay detonators and the layout of drilling patterns. Personnel should also be selected on the following criteria:

e. health and fitness;

f. family situation; and

g. leadership qualities.

Footwear

42. Footwear trialed on the reconnaissance were:

a. jandals, (wore out extremely quickly on coral);

b. sand shoes, (were found to be extremely uncomfortable when worn in water due to fines causing chaffing); and

c. "KD" sandals, (plastic, worn by majority of locals, proved to be tough, durable and comfortable). These sandals are also an issue item through RNZN.

Security

43. A 24 hour standing patrol at the magazine will be required.

Task Progress Reports

44. It is suggested that a SITREP format be established prior to deployment for use in reporting task progress. This could be communicated through the new telephone system to Apia, then to New Zealand.

Pre-Deployment Training

45. It is suggested that a programme of training be planned to prepare the team for the deployment. This could include:

a. stores preparation;

b. trade training (explosives and drilling);

c. medical lecture; and

d. local customs and language lecture.

TIME AND SPACE

Removal of Fines

46. The following calculations are for the benefit of the Office for Tokelau Affairs in determining work required to clear fines for channels and removal of rock piles (using Lieutenant D.W.S. Maloney's report for constant, for removal of fines from channel m^3/man/day = 0.5 - 0.75 m^3/day).

a. Atafu.

Total fines to be removed - 1350 m^3 (550 m^3 in channel, 800 m^3 in rock rubble piles)

so 550 m^3 @ 0.5 m^3/day/man
800 m^3 @ 1.0 m^3/day/man

∴ 27 men for 40 days clear channel and
20 men for 40 days move rock piles

b. Nukunonu.

Total fines to be removed only for area shown on drawing at Appendix 1 to Annex J - 1450 m^3.

∴ 73 men for 40 days clear channel
37 men for 80 days
20 men for 145 days

/c. Fakaofo.

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37 men for 80 days
20 men for 145 days

/c. Fakaofo.

c. Fakaofo.

Total fines to be removed - 1240 m^3
(1000 m^3 in channel, 240 m^3 in rock rubble piles)

so 1000 m^3 @ 0.5 m^3/day/man
240 m^3 @ 1.0 m^3/day/man

∴ 25 men for 80 days clear channel
(50 men for 40 days) and
24 men for 10 days move rock pile

47. All further calculations of timings have been done assuming local labour will remove all fines required for channel improvements.

Removal of Rock

48. Drilling. Timings for drilling are based on the figures shown at Annex M.

a. Atafu.

Total number of holes = 762

Overall time per 1.4 m deep hole = 4.7 mins
(see Annex M for definition of 'Overall time per hole')

Total time for drilling = 59.69 hours
say = 60 hours

Hours per day available for drilling say = 4 hours per cycle

(5 hours of work per 12.5 hourly tide cycle)

No night work so 12 hours drilling per 2 days (assuming one 4 hourly work period available for drilling per 2 days is lost due to Low Tide occurring during darkness).

Total days required for drilling = 5 days + 25% for drill jamming, breakdowns and adverse weather
say = 7 days

b. Fakaofo.

Total number of holes = 1269

Overall time per 1.4 m deep hole = 4.7 mins
(see Annex M for definition of 'Overall time per hole')

Total time for drilling = 99.41 hours

Hours per day available for drilling say = 4 hours per cycle

(5 hours of work per 12.5 hourly tide cycle)

/No night

No night work so 12 hours drilling (assuming one 4 hourly work period available for drilling, per 2 days is lost due to Low Tide occurring during darkness)

Total days required for drilling = 9 days + 25% for drill jamming, breakdowns and adverse weather
say = 11.5 days

49. Blasting. Timings used are an assessment based on desired results and a +25% factor for trialing of drilling and blasting patterns, removal of debris etc:

a. Atafu.

Prepare explosives	= 3 mins/hole
Prepare hole/loading charges/ tamping of charge	= 10 mins/hole
Layout of ring main	= 30 mins/ring main
say	= 2 mins/hole
Connecting up of charges	= 4 mins/hole
Layout shot firing cable/test continuity	= 15 mins
say	= 1 min /hole
Final check	= 1 min/hole
Total time/hole for blasting	= 21 mins
Total number of holes	= 762
Total time required for blasting	= 267 hours
Work period	= 12 hrs/2 days
Total days required for blasting	= 23 days + 25% for adverse weather
	= 29 days

b. Fakaofo.

(Time calculations as for Atafu)

Total time/hole for blasting	= 21 mins
Total number of holes	= 1269
Total time required for blasting	= 445 hours
Work period	= 12 hrs/2 days
Total days required for blasting	= 37 days + 25% for adverse weather
	= 37 days

/Total Time

Total Time Required for Task

50. a. Atafu.

Drilling	7 days
Blasting	29 days
1 day per 7 days lost due to Sunday	+ 5 days
1 day per 3 days spent disposing of debris from task site	+ 12 days
Allow 3 days for off loading stores	+ 3 days
Allow 3 days for loading stores at completion	+ 3 days
Total Time for Task	= 59 days

b. Fakaofo.

Drilling	11.5 days
Blasting	47 days
1 day per 7 days lost due to Sunday	+ 8.5 days
1 day per 3 days spent disposing of debris from task site	+ 20 days
Allow 3 days for off loading stores	+ 3 days
Allow 3 days for loading stores at completion	+ 3 days
Total Time for Task	= 93 days

c. Additional Contingencies.

Allow 7 days for stores prep/ loading ship/Customs at Apia	+ 7 days
Allow 3 days for journey on ship to Tokelau	+ 3 days
Allow 2 days for journey between Atafu and Fakaofo	+ 2 days
Allow 3 days for return journey to Apia	+ 3 days
Allow 7 days for unloading ship/ Customs/R & R•at Apia	+ 7 days
Total time arrive Apia, undertake tasks and depart Apia for New Zealand	= 174 days (approximately 5 1/2 months)

/51. All

51. All timings assuming ship schedule is co-ordinated with intended movements of team.

PRIORITY OF WORK

52. Removal of fines from channel bottom at Atafu and Fakaofo is to be complete prior to task commencing. This will allow easy off loading and loading of drilling equipment at wharfs.

53. It is suggested that work at Atafu be done first because the volume of fines at Atafu is considerably less than that at Fakaofo, this will give locals at Fakaofo more time to complete the removal.

CONCLUSIONS

54. The following are conclusions:

a. General.

(1) The Atafu reef channel requires widening on both the LHS and RHS at the channel entrance.

(2) The channel at Nukunonu requires deepening, but this involves the removal of fines only. and is not considered an Army task.

(3) The Fakaofo reef channel, at Fale, requires widening on LHS.

(4) Atafu and Fakaofo channels also require the removal of fines from the channel bottom, this is not considered an Army task.

(5) The channels are being used as rubbish tips.

(6) No routine maintenance is being conducted on any of the channels.

(7) Piles of loose rock at the edge of the channels contribute to the infilling of the channel with fines.

(8) Fines must be cleared from the channels, to allow efficient off loading of stores, prior to task commencing.

(9) Local people believe all work associated with the maintenance and improvement of reef channels is not their responsibility.

b. Reconnaissance.

(1) The reef channel reconnaissance party was grossly undermanned and had very little depth of surveying experience.

/(2) Guidance

(2) Guidance on the design for reef channel improvements, was required from a qualified Civil Engineer.

(3) A test drill and blast of the coral is required for planning data.

(4) This reconnaissance established an accurate survey grid for future reference of charges in the channels.

(5) The Army "Anglo", staff used on the reconnaissance became unserviceable very quickly in the humid environment due to age and difficulty of carriage.

(6) The allowances were mishandled due to interdepartmental misinterpretation.

c. Proposed Task.

(1) The long task duration will be demanding personally and professionally. This will require carefully selected personnel.

(2) There is no resupply readily available, therefore, the team must deploy totally self sufficient.

(3) New Zealand personnel will find Tokelau food very monotonous and unsubstantial for the work required. Fresh rationing is required from stocks take to Tokelau, a fridge approximately 2 m^3 is also suggested.

(4) An airtrack drill and compressor are required for the execution of the tasks.

(5) European style accommodation for the team will foster a good rapport amongst the team members and ensure a degree of privacy.

d. Shipping.

(1) The shipping schedule to Tokelau is very limited.

(2) The team will require a large deck area for storage of cargo.

e. It would be beneficial for personnel selected for the team to be given a pre-deployment lecture of Tokelau way of life, protocol and customs.

f. The team will require time prior to deploying, for the procurement and packaging of stores necessary for the task.

g. Timings. The following are the timings for each task:

(1) Atafu. To remove:

(a) 550 m^3 from channel (using local labour) 27 men for 40 days.

(b) 800 m^3 In loose piles (using local labour) 20 men for 40 days.

(c) 900 m^3 Of rock:

(i) drilling of boreholes - 7 days.

(ii) Blasting - 29 days.

(2) Nukunonu. To remove:

(a) 1450 m^3 From channel (using local labour) 37 men for 80 days.

(3) Fakaofo. To remove:

(a) 1000 m^3 from channel (using local labour) 25 men for 80 days.

(b) 240 m^3 In loose piles (using local labour) 24 men for 10 days).

(c) 1500 m^3 Of rock:

(i) drilling of boreholes - 11.5 days.

(ii) Blasting - 37 days.

(4) Total Time for Task at Atafu. 59 Days.

(5) Total Time for Task at Fakaofo. 93 Days.

(6) Total Number of Days of Work Required to Complete Both Tasks. 152 Days.

(7) Total Time on Deployment. (Arrive Apia, undertake tasks and depart Apia for New Zealand). 174 Days.

RECOMMENDATIONS

55. The following points are recommended:

a. RNZE undertake the task of improving the reef channels at Atafu and Fakaofo.

b. No work commences on the improvement of channels until the locals have removed the infill of fines and necessary piles of rubble.

/c. The purchase

d. The purchase of one x P375 portable compressor, 4 x wheeled, adjustable tow bar, c/w rubber hose, steel piping and spares be initiated as soon as possible.

e. A programme of routine maintenance be established. This could be overseen and directed by the Public Works organisation.

f. Rubbish is no longer allowed to be disposed of in the reef channels.

g. The schedule of the dates of charter for the cargo ship be organised to coincide with the proposed movements of the team.

h. The task personnel should concentrate for a period of approximately four weeks prior to departure for Tokelau. This period should be used for:

(1) briefings;

(2) checking of stores; and

(3) familiarisation courses on new equipments and refresher courses on trade related skills.

i. A good standard of accommodation be made available for the team whilst in Tokelau.

j. A cook should be included in the team complete with 'tools of the trade' and European style fresh rations. A commercial style refrigerator approximately 2 m^3 is also recommended.

k. The suggested stores list at Annex O be considered in more depth because of the requirements for the team to be self sufficient.

l. On future reconnaissances of this nature:

(1) the survey team should include:

(a) one x officer,

(b) one x surveyor (tradesman),

(c) two x RNZE personnel, and

(d) one x Civil Engineer (to assess the locals' requests and offer guidance for the final designs).

(2) Arrangements are made for the required equipment and stores for test drilling and blasting be made available.

m. A modern, light weight staff be introduced to the Army to replace the current stock of outdated items. A suggested replacement is:

(1) the 5 m staff produced by 'MIZOGUCHI MFG' CO LTD, JAPAN. It comes complete with nylon carry bag, is easy to observe and has three telescopic extensions. This is currently used by Ministry of Works and Development.

n. Survey equipment be purchased for Tokelau and periodically used to monitor the infill of the channels.

o. The personnel selected for the team are considered with the following in mind:

(1) compatibility;

(2) leadership;

(3) knowledge of explosives; and

(4) personal home life.

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

SECTION A - ATAFU

General

1. The reef channel at Atafu has been developed, using explosives from an existing natural channel entrance. The last work done on the channel was in 1979 when coral heads, causing obstructions in the channel entrance, were blasted. Atafu has an excellent concrete wharf at the end of the channel.

Statistics

2. Atafu reef channel is on the north-western side of the atoll at Vao Island (Atafu Village).

Serial	Subject	Description	Referring Appendix to Annex I
(a)	(b)	(c)	(d)
	Channel		
1	Magnetic Bearing	4340 ₥	1
2	Length	140 m	1
	Datum		
3	Description	Top of LH Mooring Bollard	1, 4
4	RL	100.00	1, 4, 5
5	Distance to SCL	32.6 m	1, 4
6	Magnetic Bearing to SCL	2680 ₥	1, 4
	Survey Control Line		
7	Magnetic Bearing	4340 ₥	1
8	Number of Points Surveyed	16	1, 4
	Cross-Sections		
9	Magnetic Bearing	5940 ₥	1
10	Number of Cross-Sections	15	2, 3

/Improvements

Serial	Subject	Description	Referring Appendix to Annex I
(a)	(b)	(c)	(d)
	Improvements		
11	Requirements	Widen channel on RHS from cross-section E	1, 2, 3
		Widen entrance on RHS	
		Widen entrance on LHS	
12	Magnetic Bearing of Excavation	LHS 3650 ḿ RHS 4780 ḿ	1 1
13	Length of Excavation	LHS 58 m, RHS 45.6 m	1
	Tide Levels		
14	High Tide	RL 100.257	1, 4, 5
15	Low Tide	RL 99.107	1, 4, 5
16	Spring Low Tide	RL 98.807	1, 4, 5
17	Other structures	Wharf RL 100.157	1 , 5
18	Distance to closest	56 m (Copra Shed)	1
19	Survey references points	Nil, use magnetic bearing and distance No permanent marks available	
20	Other tasks	Removal of rock rubble piles and excavation of fines	
	Volumes for Removal		
21	Rock	898.15 m^3 say 900 m^3	1, 2, 3, 7
22	Fines	510.45 m^3 say 550 m^3	1, 2, 3, 4, 7
23	Total	1408.6 m^3 say 1450 m^3	1, 2, 3, 7

Detailed Survey

3. The survey of the Atafu Reef channel was conducted during the period 3 - 11 March 1985.

4. Cross Sections A - L were accurately surved using a level, staff, tape and compass. Sea conditions past Cross-Section L did not allow for any accurate surveying due to swell and surge of waves. Cross-Sections M, N and O were reconnoitred using tape and compass only. To compensate for the lack of accuracy a percentage accuracy ratio must be applied to each of the Cross-Sections depending on the type of method used to gain the Cross-Section data. Cross-Sections A - L must be considered applying

a ± 10% factor and Cross-Sections M, N and O applying a factor of ± 20%. The removal of all rock at Atafu requires drilling and blasting. The coral has an extremely hard crust (see Annex E), and in attempting to place permanent survey marks, consisting of plastic discs secured by bridging spikes, the spikes did not penetrate the coral at all but bent very easily. All drilling at Cross-Sections M, N and O will be under water at approximately 0.1/0.2 m plus wave surge.

Air Tools

5. When determining the type of drilling equipment to be recommended for the task, the distance between the site for the compressor (above high tide level) and the closest point to be drilled, must be considered. Assuming the compressor will operate from wharf, there is a distance of 80 m to the closest point to be drilled. Compressed air piping, rather than rubber, should be considered for this because of the high psi loss due to friction over a large distance in rubber pipes. The depth of infill, or kilikili, in the Atafu channel was not auccurately measured, but it is assumed, using local knowledge and Annex D, to be greater than 1.0 m deep. This means that all excavation required to achieve the LT - 1.2 m minimum depth specification, does not require any drilling or blasting. Deepening of Atafu channel is therefore not considered an Army task. See Appendices 2, 3 and 7 to Annex I.

Improvements

6. Improvements of the Atafu reef channel are:

a. widening an RHS by 2.0 m from Cross-Sections E - I,

b. widening the channel at the entrance on LHS at magnetic bearing of 3650 ṁ, and

c. widening the channel at the entrnace on RHS at magentic bearing of 4780 ṁ.

These improvements necessitate removal of the rock rubble piles on RHS of channel. These piles are debris ex-original construction and were manhandled into piles, therefore no problems to remove (see Annex I, Appendices 1 and 2). The rock piles are currently on the extreme edge of both sides of the channel and consists of approximately 400 m^3 each. When observing the action of the sea as it moves from High Tide to Low Tide, it appears that the receding water drags large quantities of fines from the rock pile into the channel. The fines appear to be the products of erosion upon the rock piles and, therefore, are being constantly produced through wave action. At High Tide, the water totally submerges all of the rock piles. Additional depth would be maintained if dumped rubbish was not discarded into the channel. There was no evidence that any form of routine maintenance was being periodically conducted. If this was done it would ensure continued serviceability of the channel.

/Accommodation

Accommodation

7. There is a European style guest house on Atafu for use and accommodation of official guests. The Administration Officer and his family are presently occupying it until their house is built. A second guest house, 'Modulok' type, is to be completed construction by the end of June 1985. This will include 2 x bedrooms (4 x beds), lounge, kitchen, bathroom, shower, flush toilet, electric lights and power (when generator is operating), able to sleep up to 10 personnel. This would be made available for use by the Aid team.

Resources

8. The Aumaga will provide local labour as and when required. The only pieces of machinery on the Island are 2 x small concrete mixers. A quantity of hand tools in various states of repair are available for general use.

Explosive Storage

9. There are no buildings available for the storage of explosives. The most suitable site for a magazine is on the northern side of Atafu Village approximately 250 m into the bush. Village occupies all available cleared area. Locals keep their pigs nearby, this would mean a standing patrol to be kept on magazine 24 hours a day. The local people are extremely inquisitive.

Explosives Required

10. See Annex L.

Stores Required

11. See Annex O.

Manning

12. See Annex P.

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

SECTION B - NUKUNONU

General

1. The Nukunonu reef channel is in good condition and serves the Village of Nukunonu well. The channel is an area of the reef where the sea conditions are apparently always calm. The channel is relatively wide (average approximately 30 m) and has never caused any problems for access into and out of the channel. Towards the LHS of the channel, the movement of the sea water at high tide has scoured out a deeper channel (see Appendix 1 to Annex J). This deeper area of the channel is used particularly by the boats at low tide (see Appendix 2 to Annex J). The continual silting up of the channel due to sea action is a problem.

Statistics

2. The Nukunonu channel is situated on the south western side of the atoll at Nukunonu Island (Nukunonu Village).

Serial	Subject	Description	Referring Appendix to Annex J
(a)	(b)	(c)	(d)
	Channel		
1	Magnetic Bearing	3960 ₥	1
2	Length	130 m	1
	Datum		
3	Description	Bottom RH corner of footpath	1
4	RL	100.00	1
5	Distance to SCL	36 m	1
6	Magnetic Bearing to SCL	4950 ₥	1
	Survey Control Line		
7	Magnetic Bearing	3960 ₥	1
8	Number of Points Surveyed	4	1

/Cross-

Serial	Subject	Description	Referring Appendix to Annex J
(a)	(b)	(c)	(d)
	Cross-Sections		
9	Magnetic Bearing	2360 ø	1
10	Number of Cross-Sections	4	3
	Improvemets		
11	Requirements	Locals mentioned widening at RHS entrance - absolutely no need. Requires deepening particularly at shore	1, 2
	Tide Levels		
12	High Tide	RL 99.889	1, 3
13	Low Tide	RL 98.2	1 , 3
14	Spring Low Tide Spring High Tide	RL 98.00 RL 100.519	1 , 3
15	Other structures	Nil	
16	Distance to closest building	21 m (Stores Fale)	1
17	Survey references points	Nil, use magnetic bearing and distance no permanent marks available	
18	Other tasks	Prevention of wave action dragging coral beach sand from beach into channel	1
	Volumes for Removal		
21	Rock	Nil	
22	Fines	1426.8 m^3 say 1450 m^3	1, 2, 4
23	Total	1426.8 m^3 say 1450 m^3 - only for area detailed at Appendix 1 to Annex J	1, 2, 4

Detailed Survey

3. The survey of the Nukunonu reef channel was conducted on 28 February 1985. The survey was conducted using survey equipment. A SCL was established on the RHS of the channel but is

/submerged

submerged at all times. The Cross-Sections shown at Appendix 2 to Annex J and the volume calculations at Appendix 4 to Annex J, must have an accuracy ratio of ± 10% applied.

4. The only improvement required at Nukunonu is deepening of the channel, particularly at the shore (see Appendix 2 to Annex J). This inolves the removal of fines only and is therefore not considered an Army task.

ENGINEER RECONNAISSANCE REPORT

ON ENGINEER WORKS REQUIRED

TO IMPROVE THREE EXISTING REEF CHANNELS

ON TOKELAU ISLANDS

SECTION C - FAKAOFO

General

1. The reef channel at Fakaofo was constructed by RNZE during 1963/64. Due to a poor reconnaissance and subsequently, a poor estimation of time, work and explosives requirements was done. The 1963 team, led by Lieutenant D.W.S. Maloney, left Fakaofo having not completed their task. Work was continued on improving the channel by RNZE, during the following 24 months. The cause of the problem at Fakaofo is the incorrect alignment of the channel to the breaking waves, causing difficulty in manoeuvreing boats in the channel entrance. The construction of the channel at this angle was intentional to stop the wave surge up channel. This appears now to have been an incorrect judgement and was made prior to the channel construction commencing.

2. During 1981, a team led by Mr P. Asher, constructed an additional channel on Fakaofo to that existing at Fale. This new channel was constructed to the north west of Fakaofo atoll on the northern side of the reef at a cost of NZ$75,000. It linked the Island of Fenua Fala to the open sea.

3. Fenua Fala is a large Island approximately 1.5 km north west of Fale. It is a spacious Island and accommodates approximately 100 people of the Fakaofo population. Fale however, is a very small Island and is incredibly over crowded. It is reported to be the most densely populated Island in the Pacific Ocean, being the size of less than 2 x rugby fields, it has a population of over 500 people.

4. The continued inhabitation of Fale stems back to it being the tradition 'capital' of Fakaofo. Over recent years, the Fakaofo population has been encouraged to move to Fenua Fala by the Ministry of Foreign Affairs.

5. Previous aid teams have constructed the only school and hospital there and the recent construction of a new channel makes Fenua Fala a far more desirable place to live. However, the locals will not move and have begun to outlaw those who have begun living in Fenua Fala. They are now not allowed to voice their opinions individually at the weekly meetings of the Taupulaga and the number of their respresentative Elders has been reduced.

6. The new channel has proved to be excellent in all respects, such as:

a. construction;

b. siting; and

/c. accessibility.

c. accessibility.

However, it is only permitted to be used in extreme emergencies, such as a life or death situation when the Fale channel is totally inaccessible. The Fenua Fala channel is therefore wasted. This indicates the abrupt and perhaps stubborn manner of the local people. They believe that their points of view and opinions are always correct and this often means it is difficult to get them to accept any outside advice. See para 26 of Part II.

Statistics

7. The Fakaofo channel is on the south western side of the atoll at Fale Island (Village).

Serial	Subject	Description	Referring Appendix to Annex K
(a)	(b)	(c)	(d)
	Channel		
1	Magnetic Bearing	4200 ⌀	1
2	Length	180 m	1
	Datum		
3	Description	Front RH corner of copra shed on wharf at ground level	1 , 4
4	RL	100.00	1, 4, 5
5	Distance to SCL	11.5 m	1, 4
6	Magnetic Bearing to SCL	5030 ⌀	1, 4
	Survey Control Line		
7	Magnetic Bearing	4320 ⌀	1
8	Number of Points Surveyed	18	1, 4
	Cross-Sections		
9	Magnetic Bearing	2720 ⌀	1
10	Number of Cross-Sections	18	2, 3
	Improvements		
11	Requirements	Widen channel on LHS from patch of concrete on LH channel side at Cross-Section	1, 2, 3

Serial	Subject	Description	Referring Appendix to Annex K
(a)	(b)	(c)	(d)
12	Magnetic Bearing of Excavation	3950 ml	1
13	Length of Excavation	118 m	1
	<u>Tide Levels</u>		
14	High Tide	RL 99.944	1, 4, 5
15	Low Tide	RL 98.894	1, 4, 5
16	Spring Low Tide	RL 98.694	1, 4, 5
17	Other structures	Channel has concrete area around three x sides up to 21.5 m up channel. Recently constructed sea wall 2.0 m high. Old derrick on wharf.	1
18	Distance to closest building	6.6 m	1
19	Survey reference	Nil, use magnetic bearing and distance, no permanent marks available	
20	Other Tasks	Removal of rock rubble pile and excavation	2, 3, 4, 6
	<u>Volumes for Removal</u>		
21	Rock	1454.75 m^3 say 1500 m^3	1, 2, 3, 7
22	Fines	969.15 m^3 say 1000 m^3	1, 2, 3, 4, 7
23	Total	2423.9 m^3 say 2500 m^3	1, 2, 3, 7

<u>Detailed Survey</u>

8. The survey was conducted during the period 13 - 15 March 1985. An accurate survey was done using a level, staff, tape and compass for Cross-Sections A - M. Sea conditions past Cross-Section M did not allow for any accurate surveying due to the swell and surge of waves. Cross-Sections N - X were reconnoitred using a tape and compass only. To compensate for the lack of accuracy, a percentage accuracy ratio must be applied to each of the Cross-Sections depending on the type of method used to gain the Cross-Section data. Cross-Sections A - M must be considered applying a $\pm$ 10% factor and Cross-Sections N - X applying a factor of $\pm$ 20%. Removal of all rock at Fakaofo requires drilling and blasting.

/9. Permanent

9. Permanent survey marks were intended to be placed at Fakaofo, but the coral here proved to be too hard.

10. All drilling at Cross-Sections N - X will be under water approximately 0.1 - 0.2 m plus wave surge.

Air Tools

11. The minimum distance between compressor (above High Tide) and the closest point to be drilled must be considered when determining loss of psi due to frction of rubber hose. At Fakaofo the compressor can be located near the 'pole' (see Appendix 1 to Annex K) as the coral here is always above High Tide mark. The closest point of drilling is at Cross-Section H, approximately 40 m away. This distance will require alternative piping of compressed air other than rubber to avoid excess loss of psi.

12. Local knowledge and reference to Annex D suggests that the infill of fines in the channel is in excess of 1.5 m deep. No blasting or drilling is required to enable efficient removal of fines. Excavation of channel to achieve minimum required depth of Low Tide - 1.2 m is not considered an Army task (see Appendices 2, 3, and 7 to Annex K).

Improvements

13. Improvements required at Fakaofo (Fale) channel are:

a. widening of channel on LHS at magnetic bearing of 3950 ⌀ from a patch of concrete on the LH side of channel to sea. This bi-sects a relatively small pile of rock rubble of approximately 240 m^3. This will be required to be removed prior to any work commencing on the task.

14. Regular Routine Maintenance of clearing fines from the channel is not being undertaken by the locals. This is a necessary requirement to keep the channel serviceable.

Accommodation

15. There are two large European style guest houses on Fale and three on Fenua Fala. They all consist of one large room with a capacity to sleep 12 pople comfortably, and a flush toilet. There are no cooking or washing facilities. The Taupulaga stated that Guest House accommodation would be made available for an aid team.

Resources

16. Local labour, as and when required, will be provided by Aumaga. No other resources can be relied upon.

Explosive Storage

17. Due to overcrowding explained in paragraph 3, the explosives must be stored off the inhabited Island. There is an expance of reef that remains above water level to the north west of Fale (see Annex C), the area detailed as 'old hospital' is now the Administration Block. The suggested magazine site is on a isolated area of this expanse of reef.

Other Considerations

18. The locals at Fakaofo also believe that there is insufficient concreted area at the end of the channel to allow for efficient loading/off loading of boats. They said that they also want about 7.0 m of the channel backfilled then concreted. After some advice and pursuasion, the Elders were discouraged from this course of action and were satisfied with the suggestion of concreting a larger area of the reef on both sides of the channel.

Explosives Required

19. See Annex L.

Stores Required

20. See Annex O.

Manning

21. See Annex P.

ANNEX A TO
TOKELAU RECON REPORT
DATED 10 MAY 85

Telephone: Wellington 726-499
Extension 8464, 8465

Chief Engineers Office,
Army General Staff,
Defence Headquarters,
Private Bag,
Wellington

3cd 1/1/CE

15 Feb 85

Mr B Prendergast
Senior Construction Engineer
Ministry of Works and Development
P.O. Box 12041
Wellington

Dear Brian,

TOKELAU ISLANDS RECONNAISSANCE
TERMS OF REFERENCE: LT A R SKINNER

References: A. Conference Ministry of Foreign Affairs 6th Floor 1500 hours 14 Feb 85
B. Telecon Mr David Taylor / Maj Reg Barnett of 15 Feb 85

1. The reconnaissance task to the Tokelau Islands involves Defence primarily in two main areas:

a. deepening and widening to 20/25 feet, the reef channels at Fakaofo (Fale) and Atafu; and

b. dismantling and removing to deep water a large wreck on Fakaofo (the AI SOKULA) and an older small wreck on Atafu (a fishing vessel).

/2. I understand

2. I understand also that the Tokelau authorities are also concerned that the channel on Nukunonu though of satisfactory width, may need deepening at the shoreline. An opinion on that requirement should also be included in the Defence Report.

3. Attached is a copy of Cabinet Minute 85/2/25, sub paras b(i) and ii being of relevance to this reconnaissance. A copy is also attached of Defence HQ (Policy Branch) Minute 23/19/1 dated 7 Feb 85, the contents are self-explanatory.

4. The members of the Defence reconnaissance party are Lt A M Skinner, RNZE and CPO John Kearney RNZN. Adrian Skinner has been advised to seek your guidance and assistance as regards to the final design parameters of the reef channel projects. In this respect the expert advice of Mr Peter Asher would be welcomed.

5. In any case, as agreed to by Referent and in consultation with Mr Bob Sneddon and Mr Malcolm Faulls of MOWD, the design report is to be prepared by MOWD. Needless to say, Adrian and yourself together with Peter Asher should establish a close working relationship to enable Adrian Skinner to prepare a feasibility report on Defence undertaking the work desired, subject to confirmation with the design report on return to New Zealand.

6. Adrian Skinner has been further advised that he may stay on in the Tokelau Group (for three weeks) if he perceives the requirement. I have recommended to him that he takes the opportunity / to stay

to stay in the Tokelaus for sufficient time to enable him to report on the myriad of administrative considerations which need to be addressed when mounting a team for extended periods on works projects. The design parameters and methodology for undertaking the tasks I'm hopeful that he will establish whilst you are in the Tokelaus.

7. I trust the aforegoing helps to clarify any outstanding 'terms of reference' questions that you may have.

(R A BARRETT)
Maj
for CE

Enclosures: 1. Cabinet Minute 85/2/25

2. Defence HQ (Policy Branch) Minute 23/19/1 dated 7 Feb 85

Copies to: Mr David Taylor
Ministry of Foreign Affairs
Private Bag
Wellington

Lt A M Skinner, RNZE
25 Engineer Support Squadron
Linton Military Camp

8.2.85

23/19/1

FILE
DATE
INITIALS

MINUTE

Policy Branch

DNOP
Col Ops

DEFENCE ASSISTANCE TO TOKELAU

Reference: Cabinet Minute 85/2/25 (copy attached), sub paras b(i) and (ii)

1. This is to confirm the informal requests you have received already to provide one naval officer and one Army engineer to visit Tokelau between 25 Feb and 3 Mar 1985. The charter vessel "AVONDALE" will leave and return to Apia on those dates and the Ministry of Foreign Affairs has reserved accommodation on it.

2. Objective: to prepare a report for the Minister of Defence on the feasibility - using Defence resources to the maximum extent consistent with budgetary provisions and established Defence commitments - of:

a. deepening, and widening to 20/25 feet, the reef channels at Fakaofo (Fale) and Atafu; and

b. dismantling and removing to deep water a large wreck on Fakaofo (the "AI SOKULA") and an older small wreck on Atafu (a fishing vessel).

3. Although it is not mentioned in the Cabinet Minute, the Tokelau authorities are also concerned that the channel on Nukunonu, though of satisfactory width, may need deepening at the shoreline. An opinion on that requirement should be included in the report.

4. A simultaneous reconnaissance is to be carriedout by MWD engineers, accompanied by a blasting consultant, Mr Peter Asher. Their main interest is in the feasibility of constructing coral airstrips on the atolls. If proceeded with, that too may become - at least in part - a Defence task. In any case, expertise on all three tasks should be freely exchanged by the two elements of the reconnaissance.

/5. The report

5. The report should be forwarded please via Staff channels to this Branch, for preparation of a covering submission to the Minister. It is believed that both Navy and Army have carried out reef-gapping assignments in Tokelau in the past. Reference to relevant reports may assist the recon team.

6. It is desired that the two officers be given a briefing by this Branch and the Ministry of Foreign Affairs before they depart. Could arrangements please be made for them to be in Wellington in the week beginning 18 February× at a place and time to be discussed. Photographs of the two wrecks will be available then.

7. At this stage, financing of these projects has still to be agreed, but MFA has tentatively undertaken to meet the costs of the reconnaissance. Travel to and from Western Samoa, by civil air, will be coordinated by MFA.

(J.A. FISHER)
SAO(Pol)I

7 Feb 85

× now set for 1 pm
on Wednesday
13 Feb in MFA.
Report pls to
this Branch, Rm
632, at 12.45

CABINET

RECEIVED
29 JAN 1985
CLASSIFIED
REGISTRY

CM 85/2/25

Prime Minister

Copies to:

Minister of Foreign Affairs
Minister of Finance
Minister of Transport
Minister of Pacific Island Affairs
Minister of Defence
Minister of State Services

REPORT ON OVERSEAS VISIT : RT HON DAVID LANGE

At the meeting on 28 June 1985 Cabinet:

a   noted the report attached to CS (85) 35 on your visit to Tokelau;

b   invited the Minister of Defence to provide you with a report on the feasibility of the Armed Services:

   i   widening the narrow reef passages at Fakaolo and Atafu;

   ii   removing two wrecks which are causing fish poisoning;

   iii   providing surveillance of the Exclusive Economic Zone and enforcement patrols;

c   noted that copies of your report will be referred for appropriate action or consideration to the Ministers of Foreign Affairs, Defence, State Services, Transport and Pacific Island Affairs.

CDS.

Secretary of the Cabinet

ANNEX B TO
TOKELAU RECON REPORT
DATED 10 MAY 85

118/13/109/1

MINISTRY OF FOREIGN AFFAIRS

WELLINGTON

20 February 1985

Lieutenant A Skinner
New Zealand Army
C/o Officers Mess
Linton Military Camp

Dear Lieutenant Skinner

I am authorised by the Minister of Foreign Affairs to offer you an assignment as a short term adviser to report to the Ministry of Defence on the feasibility of deepening and widening the reef channels at Fakaofo (Fale) and Atafu.

Your assignment will be for the period 23 February-22 March 1985 and will be under the auspices of the New Zealand Development Cooperation Programme.

BACKGROUND AND TERMS OF REFERENCE

The background to this assignment and the terms of reference for it are set out in Major R A Barrett's letter of 15 February to Mr Brian Prendergast, Senior Construction Engineer, Ministry of Works and Development which has been copied by Major Barrett to you. A copy of this letter is attached for your ease of reference at Annex A. In summary the reconnaisance task requires you to report to the Ministry of Defence on the following:

i deepening and widening to 20-25 feet the reef channel at Atafu.

ii deepening and widening the Nukunonu reef channel.

iii removing rubble from the existing channel at Fakaofo (Fale) and (i) realigning, widening (by 20-25 feet) and deepening it. Or (ii) investigating the development of the nearby natural channel.

ANNEX A TO
TOKELAU RECON REPORT
DATED 6 MAY 85

118/13/1009/1

MINISTRY OF FOREIGN AFFAIRS

WELLINGTON

20 February 1985

Lieutenant A Skinner
New Zealand Army
C/o Officers Mess
Linton Military Camp

Dear Lieutenant Skinner

I am authorised by the Minister of Foreign Affairs to offer you an assignment as a short term adviser to report to the Ministry of Defence on the feasibility of deepening and widening the reef channels at Fakaofo (Fale) and Atafu.

Your assignment will be for the period 23 February-22 March 1985 and will be under the auspices of the New Zealand Development Cooperation Programme.

BACKGROUND AND TERMS OF REFERENCE

The background to this assignment and the terms of reference for it are set out in Major R A Barratt's letter of 15 February to Mr Brian Prendergast, Senior Construction Engineer, Ministry of Works and Development which has been copied by Major Barratt to you. A copy of this letter is attached for your ease of reference at Annex A. In summary the reconnaissance task requires you to report to the Ministry of Defence on the following:

i deepening and widening to 20-25 feet the reef channel at Atafu.

ii deepening and widening the Nukunonu reef channel.

iii removing rubble from the existing channel at Fakaofo (Fale) and (i) realigning, widening (by 20-25 feet) and deepening it. Or (ii) investigating the development of the nearby natural channel.

It has been stressed that in looking at these options, you should consult closely with the appropriate elders. You will understand the importance of this.

The Office for Tokelau Affairs in Apia has advised that they have had a brief discussion on the question of reef passage clearance in the Pacific with Mr Godfred Shuma of the United Nations Centre for Human Settlements. Mr Shuma, a harbour engineer and based in Rarotonga, has carried out similar reef passage work in the Cook Islands. He drew attention to the need for a very careful assessment to be undertaken before any decision on widening or deepening work is made. In particular, he emphasised the need to gather extensive comments from the local people on how the sea behaves around channels under various weather conditions. We would wish you to note Mr Shuma's advice.

You are aware that during the first sector of your assignment a Ministry of Works and Development team, accompanied by a Commission for the Environment investigating officer will be undertaking a concurrent exercise. The Ministry of Works team, comprising Mr Brian Prendergast, Construction Engineer and Team Leader, Mr Warwick Hills and Mr Peter Asher, have responsibility for preparing a design and construction proposal together with a firm estimate of cost of the establishment of a land based air service in Tokelau. The Commission for the Environment officer will advise and report on the social and environmental implications of this.

It has been agreed by your Ministry and the Ministry of Works that the Works' team will liaise closely with you on engineering aspects of your assignment, and that the design report will be prepared by the Ministry of Works. You will have opportunity to discuss how this aspect should proceed with the Ministry of Works team prior to your departure and during your journey together to Tokelau.

During the assignment in Apia and Tokelau, you should liaise with the Official Secretary for Tokelau Affairs, Mr A H Macey or whichever senior member of the Tokelau Public Service he may nominate to assist you. The Office for Tokelau Affairs is situated on Savalalo Street, Apia, Phone: 20-822 or 20-823.

CONDUCT

You will appreciate that New Zealand's Development Cooperation Programme, besides providing technical assistance to the partner government countries, also serves to promote goodwill and understanding. You should make every effort to reach an understanding of those people with whom you will be working and to develop a

rapport with them. I am confident that you will avoid any course of action which could adversely affect the success of your assignment or which would reflect badly on New Zealand's reputation overseas.

REMUNERATION

Details are attached at Annex B

We should appreciate receiving written confirmation of your acceptance of this offer of appointment on the terms and conditions set out above and in the attachment/s to this letter.

We should like to wish you a successful and enjoyable assignment in Tokelau.

Yours sincerely

(R M Miller)
Director of External Aid

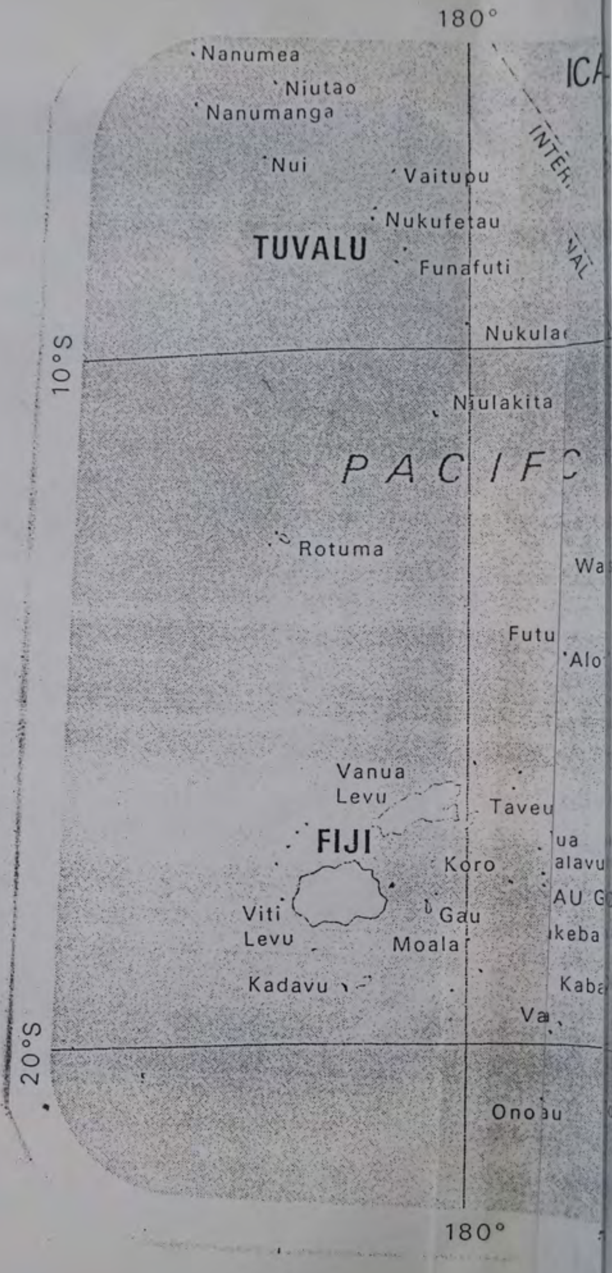
Encl

ANNEX C TO
TOKELAU RECON REPORT
DATED 10 MAY 85

MAPS

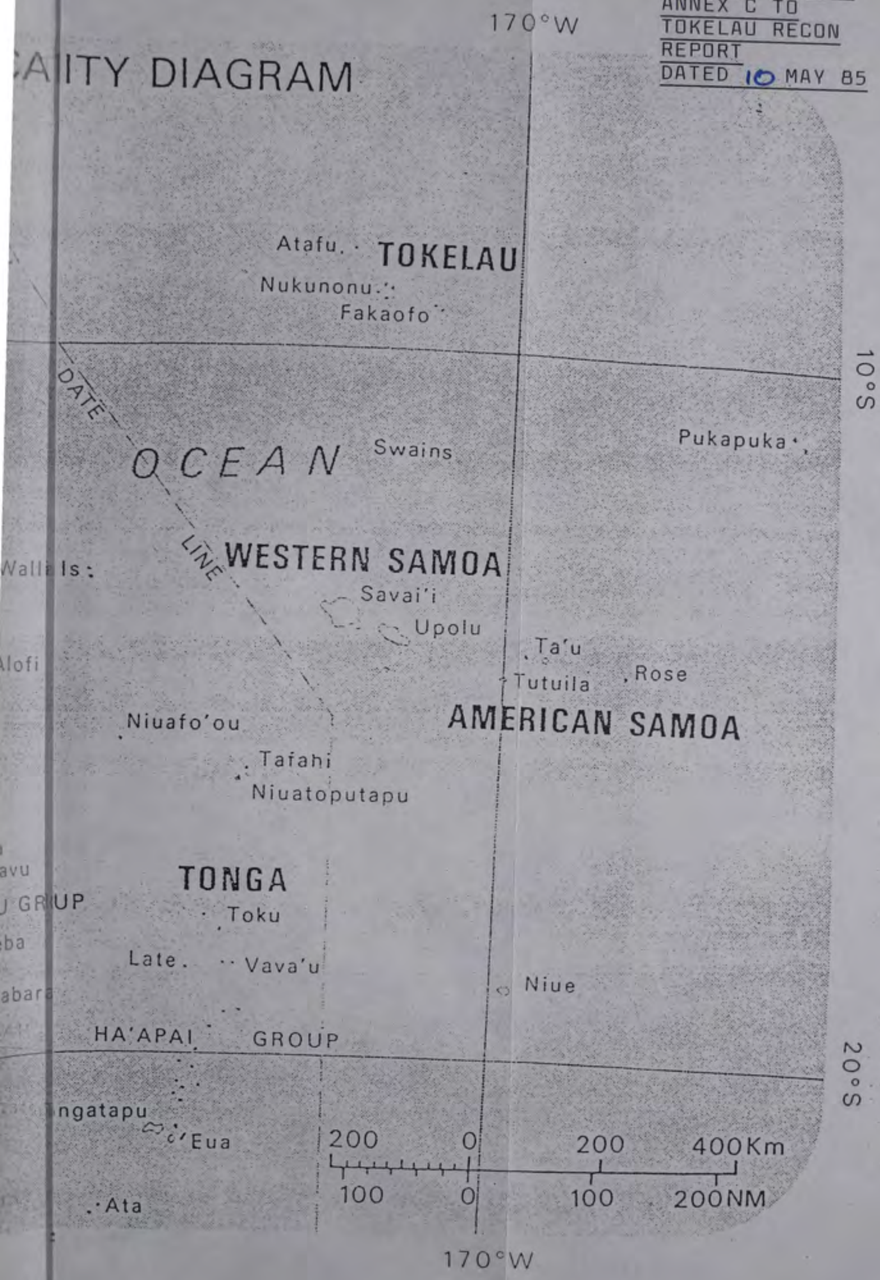
Attached as Appendices are maps of Atafu, Nukunonu and Fakaofo showing the reef channel sites and locations of the ship wrecks.

Appendices:
1. Map of Atafu
2. Map of Nukunonu
3. Map of Fakaofo

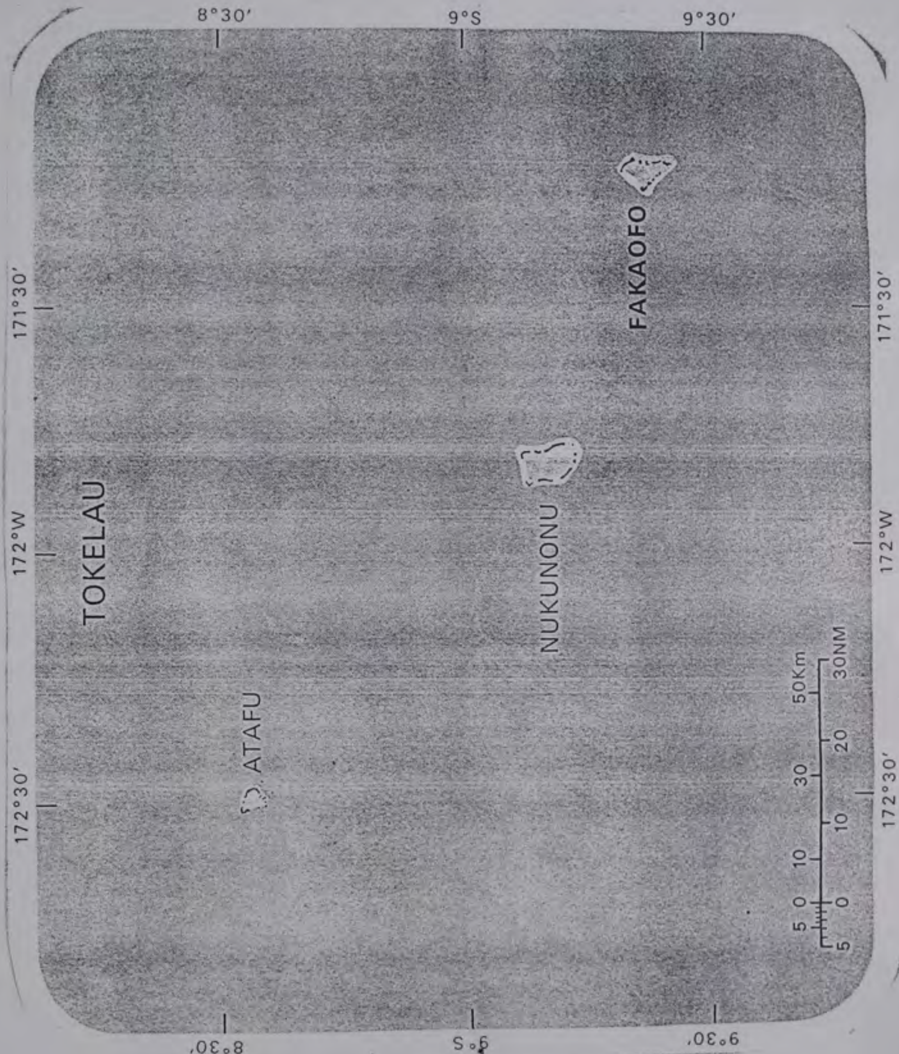


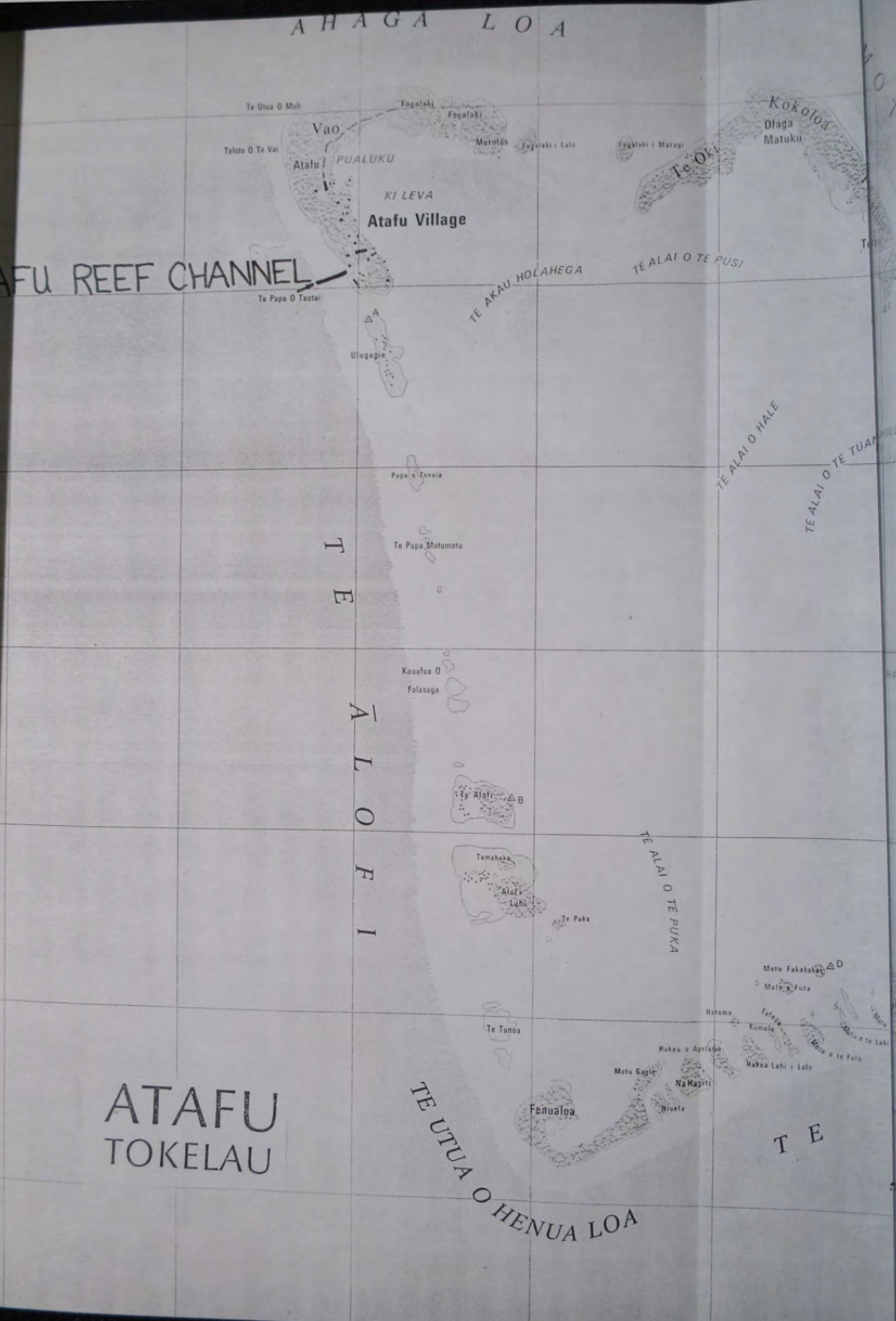
180°
Nanumea
Niutao
Nanumanga
Nui
Vaitupu
Nukufetau
TUVALU
Funafuti
10°S
Niulakita
Rotuma
Vanua
Levu
FIJI
Koro
Viti
Levu
Gau
Moala
Kadavu
20°S
180°

APPENDIX 1 TO
ANNEX C TO
TOKELAU RECON
REPORT
DATED 10 MAY 85



ANNEX C TO
TOKELAU RECON REPORT
DATED 10 MAY 85

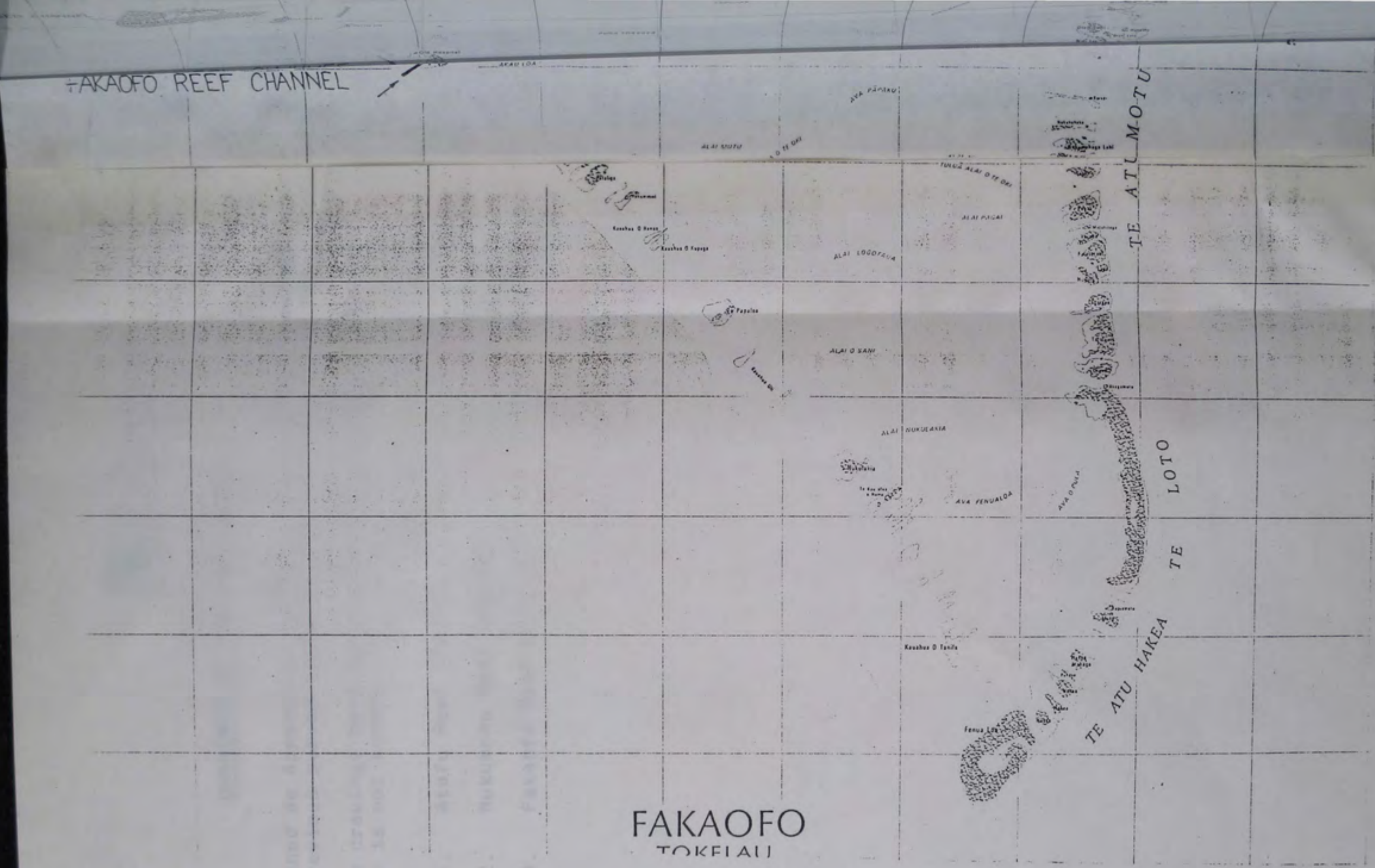




AHAGA LOA
Te Utua O Moli
Fogalaki
Vao
Teloto O Te Vai
Atafu
PUALUKU
KI LEVA
Atafu Village
Kokoloa
Ofaga Matuku
Te Oki
AFU REEF CHANNEL
Te Papa O Tautai
TE AKAU HOLAHEGA
TE ALAI O TE PUSI
Ulugagie
TE ALAI O HALE
TE ALAI O TE TUA
Papa o Tonuia
Te Papa Motumotu
TE ĀLOFI
Kauafua O Folasaga
Te Alofi
Alofi Lahi
Te Puka
TE ALAI O TE PUKA
Te Tunoa
Fenualoa
TE UTUA O HENUA LOA
TE
ATAFU
TOKELAU

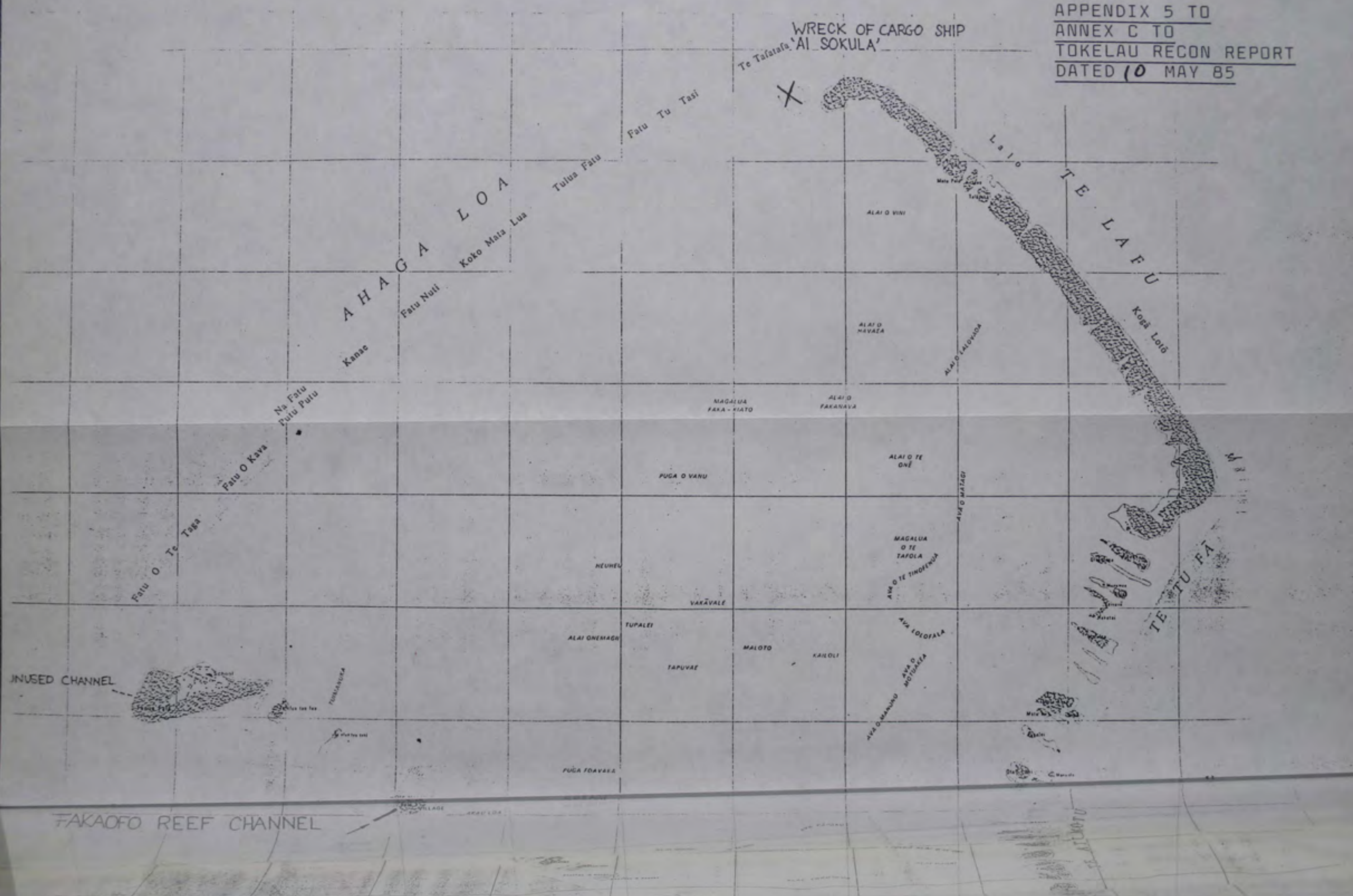
APPENDIX 3 TO
ANNEX C TO
TOKELAU RECON REPORT
DATED 10 MAY 85


NUKUNONU REEF CHANNEL
AKAU O TE MATĀKAU
AKAU LOA
AKAU TALIMOTU
Nukunonu Village
AKAU O TE VAKALELE
PUGA HOAVAKA
AKAU O TE PAPA
TE AKAU LOA
NA TAULAGA
AKAU LOA
AKAU TALIMOTU
AKAU LILIA
Muli
Falē
Nukunonu Village
Te Hale
Te Papa
Matuhaga
NUKUNONU VILLAGE
Te Tawha
TE ATU MOTU
VAIT
Te Alua
Mata Akea
Mata Fala
Kimokimoa



FAKAOFO
TOKELAU

APPENDIX 5 TO
ANNEX C TO
TOKELAU RECON REPORT
DATED 10 MAY 85



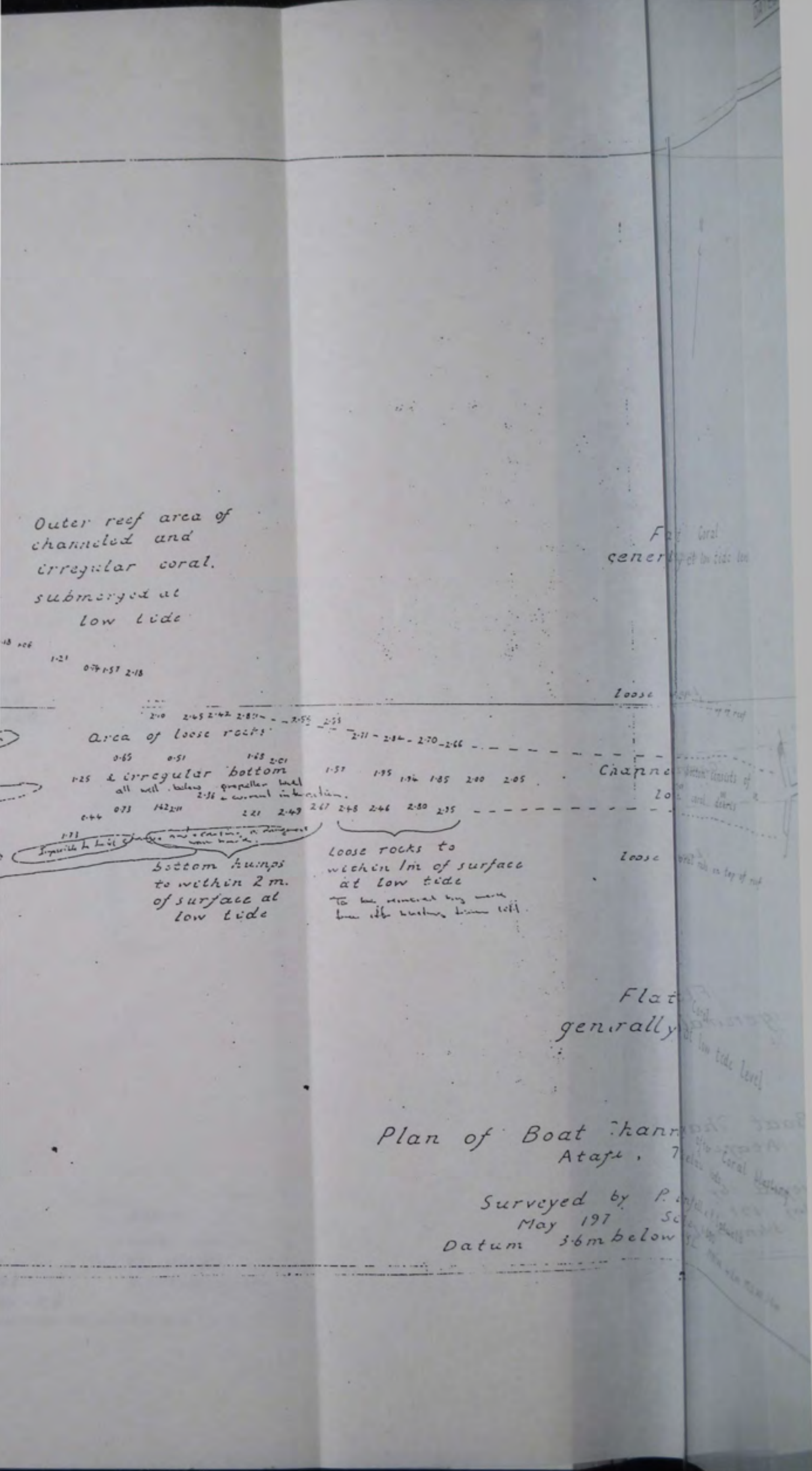
ANNEX D TO
TOKELAU RECON REPORT
DATED 10 MAY 85

DRAWINGS OF PREVIOUS SURVEY

1. Attached as Appendices to this Annex are the drawings made from a previous survey conducted during Feb and May 76.

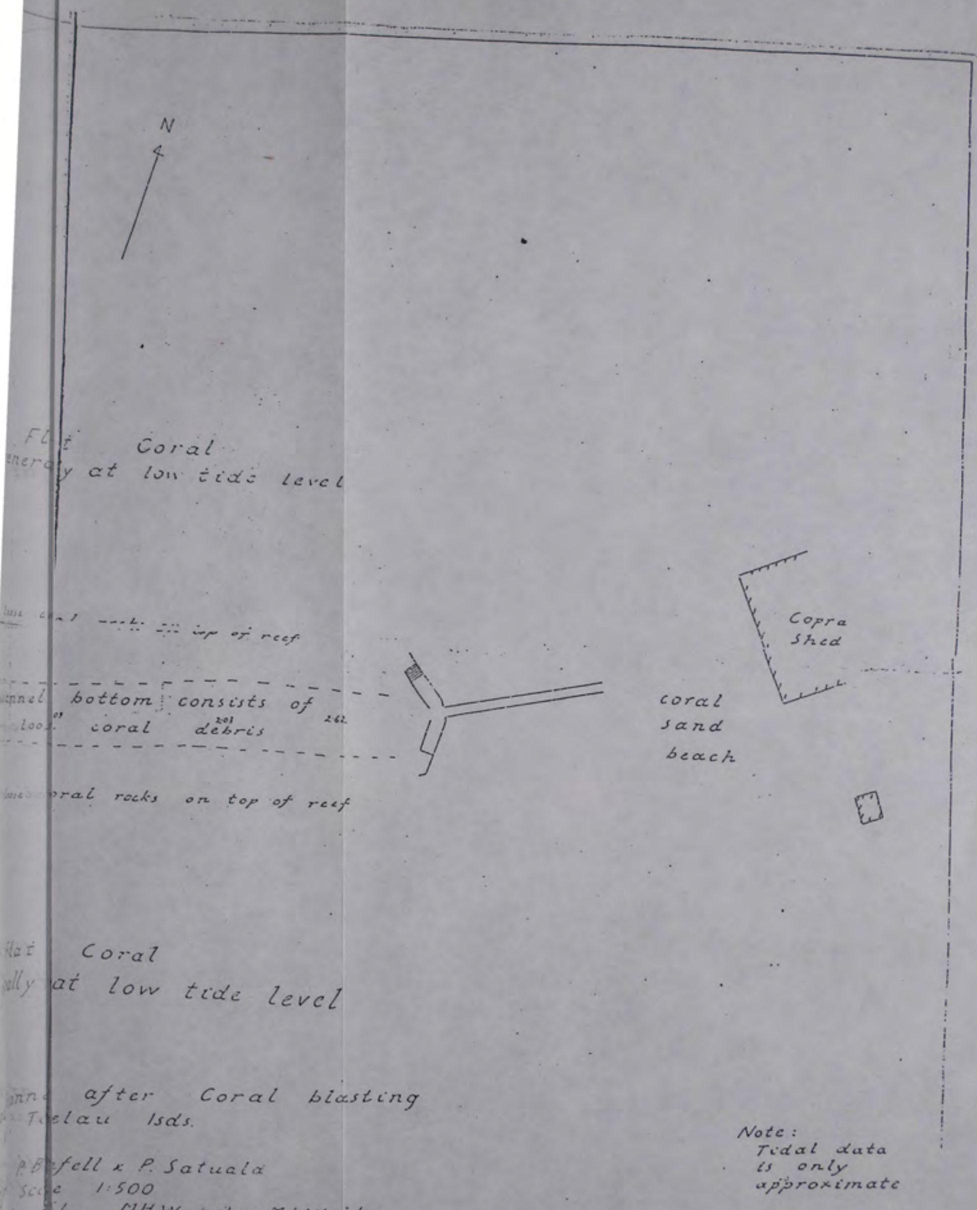
2. These drawings have been used as References, although their accuracy is not known.

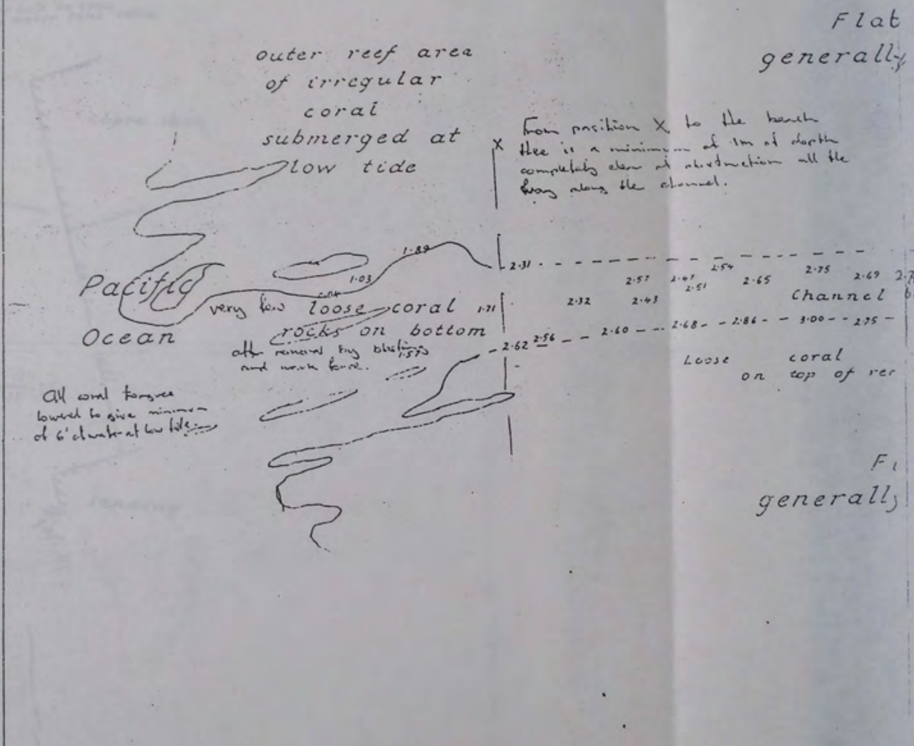
Appendices:
1. Atafu Reef Channel
2. Nukumonu Reef Channel
3. Fakaofo Reef Channel



Outer reef area of
channeled and
irregular coral.
submerged at
low tide
area of loose rocks
& irregular bottom
bottom humps
to within 2 m.
of surface at
low tide
Loose rocks to
within 1m of surface
at low tide
Loose
Channe
Loose
Flat
generally
Plan of Boat Chann
Atafu, 7
Surveyed by P.
May 197
Datum 3.6m below

APPENDIX 1 TO
ANNEX D TO
TOKELAU RECON REPORT
DATED 10 MAY 85



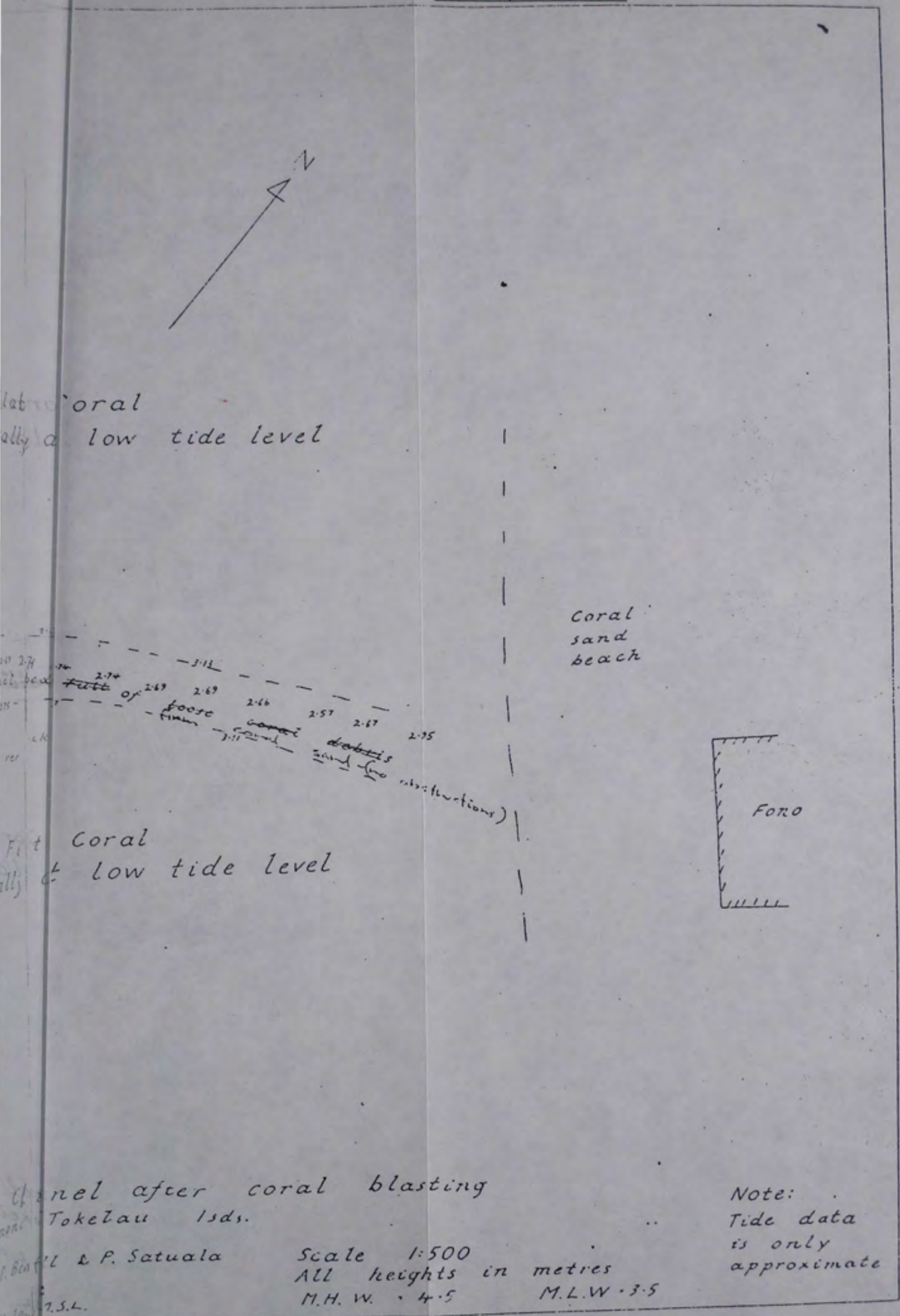


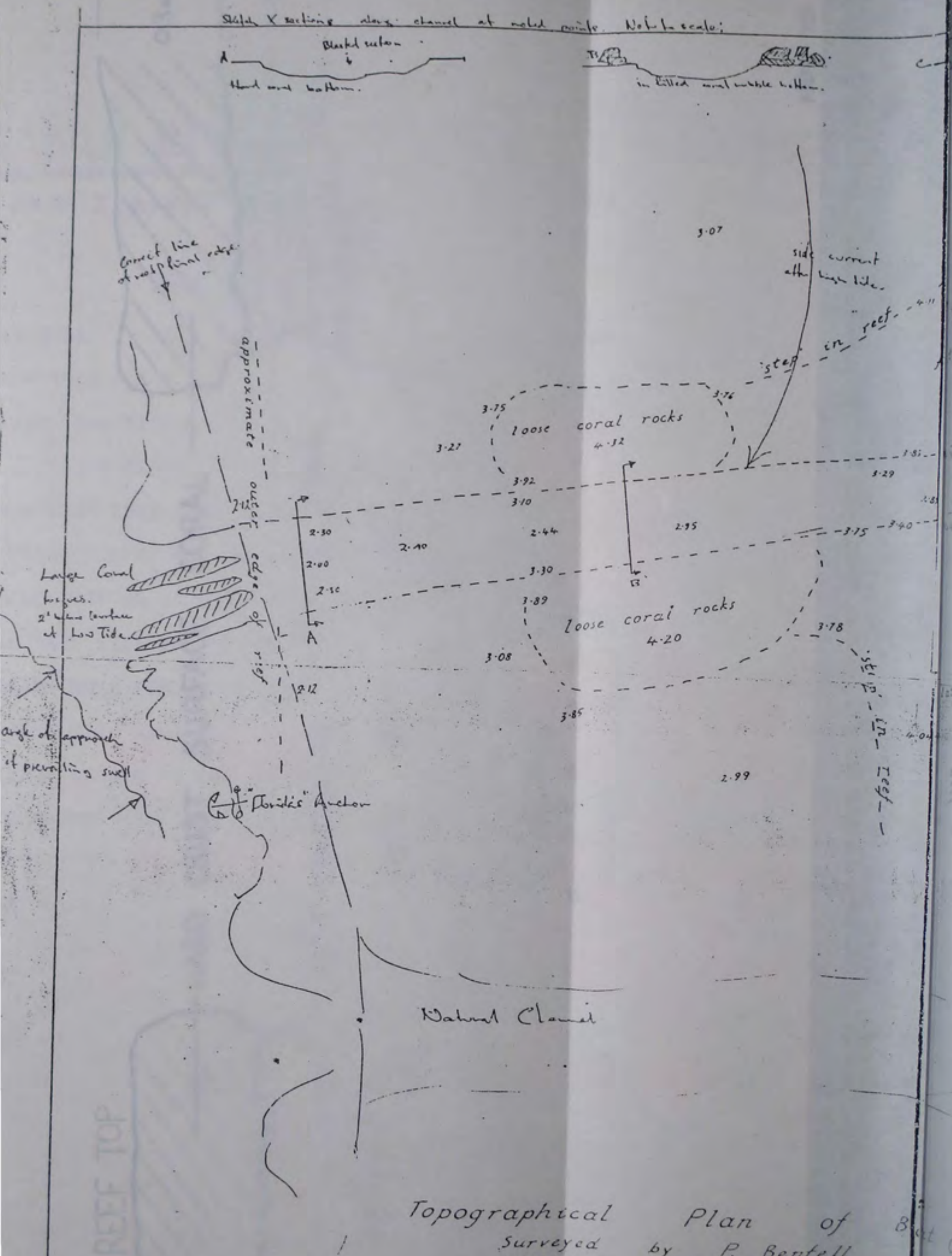
Plan of Boat Ch
Nukunonu

Surveyed by F. Ben
May 1976

Datum - 4.0m belo

APPENDIX 2 TO
ANNEX D TO
TOKELAU RECON REPORT
DATED 10 MAY 85





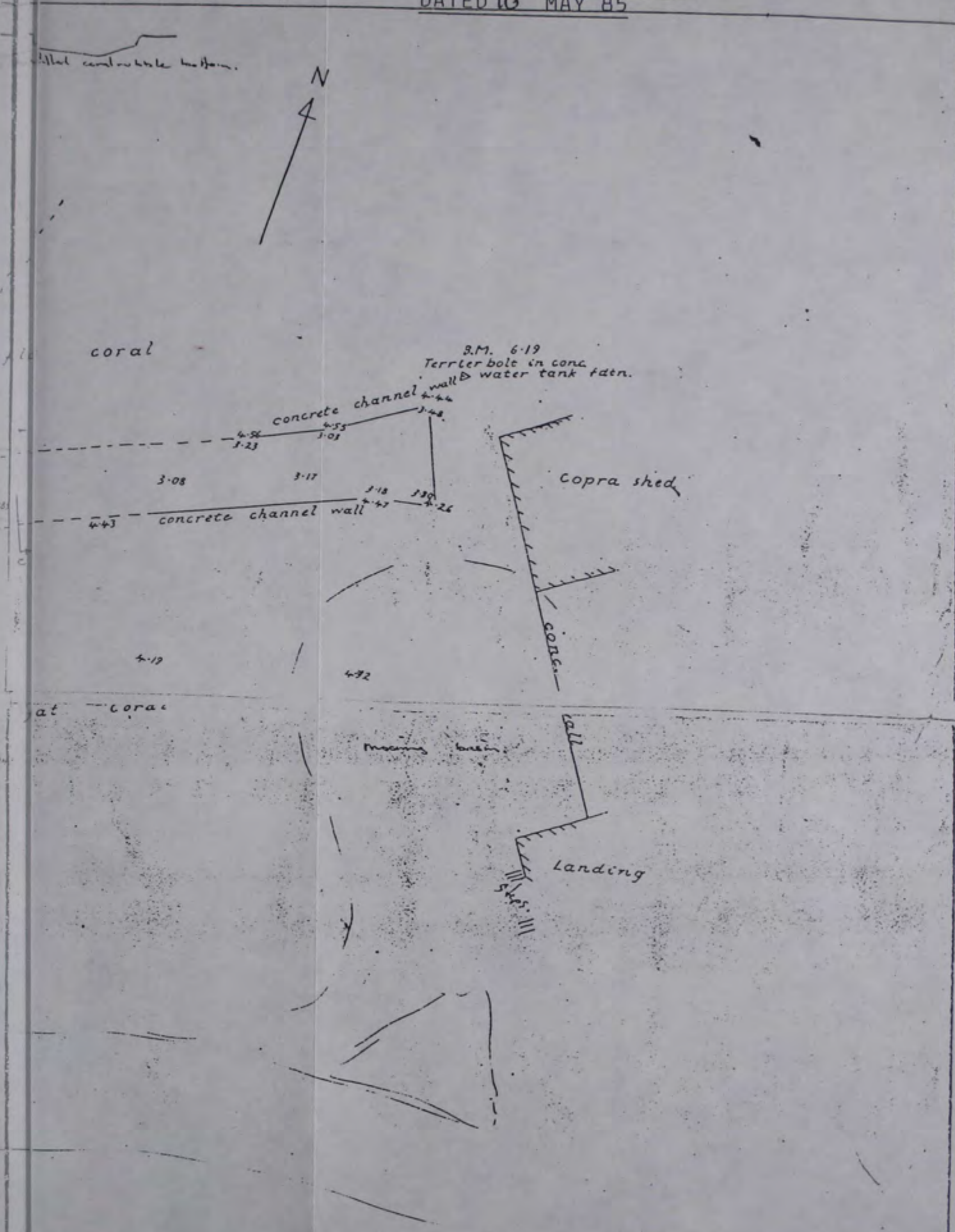
Topographical Plan of

Surveyed by P. Benfell

February 1976

Datum : 3.7 m below M.S.L.

APPENDIX 3 TO
ANNEX D TO
TOKELAU RECON REPORT
DATED 10 MAY 85



Channel, Fakaofo, Tokelau Isds.

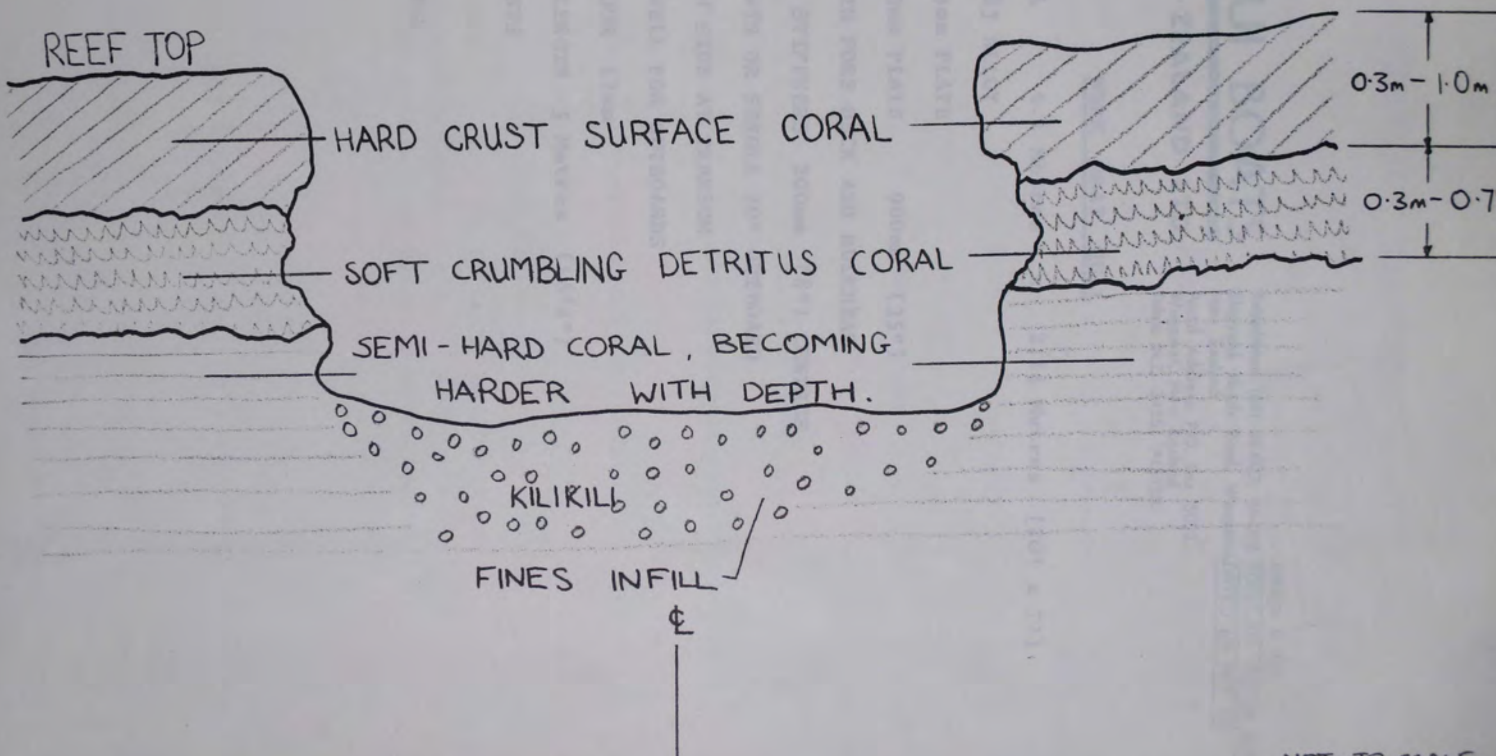
Scale 1:500
All heights in metres
M.H.W. 4·1 M.L.W. 3·3

Note: Tide information is only approximate

X-SECTION OF CORAL CRUST
(Generalized)

X-SECTION OF CORAL CRUST

(Generalised)



NOT TO SCALE

ANNEX F TO TOKELAU RECON REPO
DATED 10 MAY 85

WANGANUI BOATS

– NEW ZEALAND LTD.

Telephones: (64) 46-002, 46-022
Shipyard: Heads Road, Wanganui, New Zealand.
Postal Address: P.O. Box 8032, Wanganui, New Zealand.
Telex: N.Z. 3455, 'ALSTEEL'

WORK BOAT HULL

WORK BOAT HULL 6.1 Metres x 2.14 Metres (20' x 7')

ALL WELDED 5083 ALLOY

FLAT BOTTOM 4mm PLATE

SIDES 3mm PLATE 900mm (35")

CURVED BOW WITH FORE DECK AND BULKHEAD

CHANNEL FLOOR STIFFNERS 200mm (8") CENTRES

TRANSOM FOR TWIN OR SINGLE 20" OUTBOARD

REAR SEAT EACH SIDE AT TRANSOM

SPLASH-DRAIN WELL FOR OUTBOARDS

PLY INSIDE FLOOR 12mm

CLEAR INSIDE LENGTH 5 Metres (16'4")

4 LIFTING POINTS

4 CLEATS

HULL DRAIN BUNG

ANNEX G TO
TOKELAU RECON REPORT
DATED 10 MAY 85

TOKELAU SHIPPING SCHEDULE

1985

M V AVONDALE

12 - 28 January	Visit by Prime Minister and Budget Committee meetings
25 February - 3 March	Fuel*
9 - 19 March	General Fono at ~~Nukunonu~~ Fak…
7 - 13 May	
22 June - 2 July	Inter-Fono meetings
3 - 9 August	
14 - 23 September	General Fono
12 - 18 October	Fuel* (M V "Sami")
9 - 18 November) or) 16 - 25 November)	Committee meetings
20 - 27 December	Scholarship students' home leave

* Deck passengers not carried on fuel sailings

BOAT FARES

Deck passengers	WS$25 one way
Deck passengers with saloon meals	WS$65 one way
Cabin passengers with saloon meals	WS$95 one way

Ministry of Foreign Affairs
WELLINGTON

11 February 1985

Lt. A. Skinner

ANNEX H TO
TOKELAU RECON REPORT
DATED 10 MAY 85

NOTES OF A MEETING WITH MR GOTFRED SHUMA
(HARBOUR ENGINEER, UNITED NATIONS CENTRE FOR
HUMAN SETTLEMENTS)

Place	:	Office for Tokelau Affairs, Apia	
Date	:	19 March 1985	
Present	:	Mr G Shuma	
		Mr A Macey)	Office for Tokelau Affairs
		Mr C Perez)	
		C P O J Kearney	NZ Navy
		Lt A Skinner	NZ Army
		Ms D Almao	Foreign Affairs

Mr Shuma is a UNDP consultant currently advising theCook Islands Government on the Avatiu Harbour development scheme and reef blasting projects in the outer islands. During the meeting he offered the following general comments on reef channel construction projects and maintenance.

(A) Preliminary Survey Work

Before any construction or maintenance is carried out, it is essential to compile a record of depth soundings throughout the length of the channel. This information provides a base for measuring the rate at which silt accumulates and allows the person(s) responsible for channel maintenance to decide when clearance is necessary. Once the basic dimensions of the channel are known, local Tokelauans can be trained to take soundings at regular intervals, to plot the results on a graph and to request dreding maintenance as required. Sophisticated depth guages are not needed for this type of work. A simple lead line can be used in the deeper water (about $2\frac{1}{2}$ - 3 metres) at the channel entrance.

The optimal depth for a channel should allow for: (a) the draught of the vessel (about 4 inches for an empty aluminium whaleboat plus 12 - 18 inches for the outboard motor);
(b) a tolerance (equal to 20% of the draught) for underwater clearance and wave and swell action;
(c) a margin for silt accumulation.

In Mr Shuma's experience, the excavation for the channel should err on the deep rather than the shallow side; at the same time it should not be too deep as this increases the volume of incoming water beyond desirable limits.

(B) Explosives Work

Whether widening or realigning a channel, it is very important to employ an experienced and reliable underwater explosives expert for the job. A "trigger-happy" or untrained specialist who deviates from the engineer's design parameters can create unnecessary hazards.

To establish an appropriate drilling pattern for the explosives, details of the type of coral and required depth should be known. ICI (Explosives Division) can provide information on the suitability of certain explosives for various types of coral. Delay detonators are generally used to remove the fill. During the blasting phase, there are also opportunities for the visiting expert to train Tokelauans in underwater explosives work. If this is thought desirable, the trainees can also attend a course in explosives work offered by ICI.

(C) Retaining Walls

It is possible to reinforce the side walls of the channels provided the reefs are solid enough. This is done by keying gabian baskets into the reef with spikes. The basket netting should be coated with pvc to reduce rusting. The retaining wall should however not be built right up to the edge of the reef. It has to be realized that as boulders and other material are inevitably washed back into the channel constant maintenance is necessary.

(D) Maintenance

Channel maintenance tends to be a problem in remote islands. The clearance of rubble and silt is not regarded as a traditional task by village labour forces and unless some mechanical assistance is provided, channel upkeep tends to be neglected. It is not necessary to supply sophisticated machinery for this sort of work. A simple dragline operation using steel buckets (because the material does not float), a small 2 ton air winch, and a compressor or small engine as a backup, is adequate for the typical situation. The dragline should be designed to suit the capacity of the compressor or engine attached. An hydraulic unit can be substituted for the compressor or engine; but although it is smaller and faster to operate, it has the disadvantage of requiring more frequent servicing.

Mr Shuma recommended the use of reconditioned or second-hand rather than new equipment (which ages within two months of purchase anyway).with replacement regularly scheduled every 2 - 3 years. Any equipment ordered should be tested in simulated working conditions prior to purchase and delivery.

As reef channels generally require dredging once every six to twenty-four months, it makes sense to rotate the same equipment around all three islands and to employ one permanent team (including at least 2 trained operators) to use it. The appointment of a select operator encourage a sense of responsibility for the machinery and enhance the chances that regular servicing ~~would~~ will be carried out.

Dredging operations ~~could~~ can take up to several months depending on the accumulation of silts and kilikili. A very broad estimate of the time required could be calculated once the rate at which the dragline remove fill and the mass of the silt were known. The work should be done in the off-hurricane season.

(E) Shore Facilities

Mr Shuma recommended that every channel have a basin and a large concrete landing platform. The latter should be built just above the high water mark for ease of cargo and passenger handling. Cargo handling equipment, such as derricks, were not a necessary accessory. In his experience, derricks tended to be too slow at loading and unloading petrol drums, etc. and tended therefore not to be used. It was far more important to build an adequate landing platform for receiving and loading goods.

(F) Fale Channel

Mr Shuma also asked why the natural channel at Fale had not been developed. The explanation was that the natural channel drains water from other areas and its flow of water is too great and too strong for boat channel conditions. He said this explanation appeared valid.

D J Almao
20.3.85

ANNEX I TO
TOKELAU RECON REPORT
DATED 10 MAY 85

ATAFU REEF CHANNEL

Appendices to this Annex are the technical details of the data obtained during the surveying of the channel.

Appendices:
1. Plan View
2. 3D Plan View
3. Detailed Cross-Sections
4. Longitudinal Cross-Section
5. Survey Sheets
6. Centre-Line Levels
7. Volume Calculations

Note: Appendices 1, 2, 3 and 4 are not attached, but are separate to this Report.

APPENDIX 5 TO
ANNEX I TO
TOKELAU RECON
REPORT
DATED 10 MAY 85

Please return to nearest office of Ministry of Works and Development

Ministry of Works and Development

Levelling Sheet

Job: Atafu Reef Passage Tokelau Is

Instr.: NK 2
Type of staff: Anglo
Conditions: Hot 32°C

Observer: Skinner
Booker: "
Date: 5 Mar 85
Checked:

Job File:
Sheet:
File Ref:

Field Sheet No. 1 of 13 sheets
Plan Ref: LH Linear

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset (m)	Remarks
0.562					100.000			32.6 m	434ϕ m	Fm B/m (DATUM) To 'L' 26.8ϕ m mag
A	1.470			0.908	99.092			10	ϕ	('L' at start of traverse ie corner = A-10)
B	1.405		0.065		99.157			10	10	A-10 = 'L' corner of traverse ∴ no x-
C	1.440			0.035	99.122			10	20	section RL = 99.1 m
D	1.555			0.115	99.007			10	30	
E	1.655			0.100	98.907			10	40	
F	1.602		0.053		98.960			10	50	
G	1.690			0.088	98.872			10	60	
H	1.580		0.110		98.982			10	70	
I	1.705			0.125	98.857			10	80	
J	1.838			0.133	98.724			10	90	
K	1.878			0.040	98.684			10	100	
L	1.940			0.062	98.622			10	110	
M	1.915		0.025		98.647			10	120	
N	2.150			0.235	98.412			10	130	
O	2.250			0.100	98.312			10	140	Entrance to Natural Channel Parallel
P	2.370			0.120	98.192			10	150	Edge of Reef Finger at L tide
Q	3.100			0.730	97.462			10	160	- Always under water
R		3.900		0.800	96.662			5	165	- Edge of Reef / Finger - Very Deep Water
	0.405		0.157		100.157			100.157		Height of Wharf Deck
-	1.05	Below Wharf			99.107					Low Tide Level In Relation to Datum
+	0.1	Above Wharf			100.257					High " " " " "
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]					
	2.220		2.220		3.338	Differences				

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage
Takelau Is.
(A)

Instr. NK2
Type of staff ANGLO
Conditions Hot 32°C

Observer Skinner
Booker "
Date 5 Mar 85
Checked

Job File
Sheet
File Ref

Field Sheet No. 2
of 13 sheets
Plan Ref A

Back sight	Intermediate	Fore sight	Rise +	Fall −	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.399					100.00	-0.908	99.092	ϕ	98.53	F.M. LH Side 58ϕϕ m mag (A)
	1.55			0.151	99.849		98.941	18		LH Rock ℄
	1.523		0.027		99.876		98.968	25		Just before edge of shelf.
	1.345		0.178		100.054		99.146	27		
	2.445			1.1	98.954		98.046	29		
	2.387		0.058		99.012		98.104	31		
	2.338		0.049		99.061		98.153	33		
	2.232		0.106		99.167		98.259	35		
	2.17		0.062		99.229		98.321	37		
	2.05		0.12		99.349		98.441	39		
	1.54		0.51		99.859		98.951	41		
	1.532		0.008		99.867		98.959	43		
	1.535			0.003	99.864		98.956	45		
	1.565			0.03	99.834		98.926	47		RH Rock ℄
		1.248	0.317		100.151		99.243	64		Hard, Relatively Unweather Coral, Covered only at High tide.
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]					
	0.151		0.151		0.151	Differences				

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage Tokelau Is (3)	Instr. NK-2 Type of staff Anglo Conditions Hot 32°C	Observer Skinner Booker " Date 5 Mar 85 Checked	Job File Sheet File Ref	Field Sheet No. 3 of 13 sheets Plan Ref B

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.358					100.00	-0.843	99.157	Ø	98.595	FM LH Side 59.40m mag (B)
	1.122		0.236		100.236		99.393	18		LH Rock ℄
	1.567			0.454	99.782		98.937	25		Just Before edge of shelf.
	2.415			0.889	98.943		98.100	27		
	2.605			0.19	98.753		97.91	29		
	2.455		0.15		98.903		98.06	31		
	2.353		0.102		99.005		98.162	33		
	2.247		0.106		99.111		98.268	35		
	2.018		0.229		99.34		98.497	37		
	1.407		0.611		99.951		99.108	39		
	1.302		0.105		100.056		99.213	41		
	1.237		0.065		100.121		99.278	43		RH Rock ℄
		1.502		0.265	99.856		99.013	64		(As for #2)

Differences [illegible]

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage
TOKELAU IS
C

Instr. NK-2
Type of staff ANGLO
Conditions HOT 32°

Observer Skinner
Booker "
Date 5 MAR 85
Checked

Job File
Sheet
File Ref

Field Sheet No. 4
of 13 sheets
Plan Ref C

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.398					100.00	-0.878	99.122	0	98.56	FM LH Side 59.40 m mag C
	1.068		0.33		100.33		99.452	18		LH Rock ℄
	1.488			0.42	99.91		99.032	25		Shelf edge
	2.391			0.903	99.007		98.129	27		
	2.418			0.027	98.98		98.102	29		
	2.38		0.038		99.018		98.14	31		
	2.305		0.075		99.093		98.215	33		
	1.836		0.469		99.562		98.684	35		
	1.406		0.43		99.992		99.114	37		
	1.22		0.186		100.178		99.3	39		
	1.183		0.037		100.215		99.337	41		
	1.275			0.092	100.123		99.245	43		RH Rock ℄
		1.425		0.15	99.973		99.095	64		(As #2)
1.398		1.425	1.565	1.592	99.122					
	0.027		0.027		0.027					

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage TOKELAU 13 (D)	Instr. NK-2 Type of staff ANGLO Conditions HOT 32°C	Observer Skinner Booker " Date 5 MAR 85 Checked	Job File Sheet File Ref	Field Sheet No. 5 of 13 sheets Plan Ref D

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.368					100.00	-0.993	99.007	0		FM LH. Side 59.4ϕ m mag (D)
	1.032		0.336		100.336		99.343	18		LH ROCK ℄
	1.372			0.340	99.996		99.003	25		Shelf edge.
	2.452			1.080	98.916		97.923	27		
	2.450		0.002		98.918		97.925	29		
	2.455			0.00.	98.923		97.92	31		
	1.727		0.728		99.651		98.648	33		
	1.203		0.524		100.175		99.172	35		
	0.935		0.268		100.443		99.44	37		
	0.887		0.048		100.491		99.488	39		
	0.927			0.04	100.451		99.448	41		
	0.968			0.041	100.41		99.407	43		ROCK ℄ RH
		1.460		0.492	99.918.		98.915.	64		(AS # 2)

0.092 | 0.092 | 0.092 Differences

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Ministry of Works and Development

Levelling Sheet

Job: Atafu Reef Passage
Tokelau Is.
(E)

Instr.: NK-2
Type of staff: ANGLO
Conditions: WARM Scattered cloud.

Observer: Skinner
Booker: Matulino
Date: 6 Mar 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 6 of 13 sheets
Plan Ref: E

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.543					100.00	-1.093	98.907	∅	59.4∅ mp	mag
	1.048		0.495		100.495		99.402	18		LH Rock ℄
	1.569			0.521	99.954		98.881	25		Edge shelf
	2.533			0.964	99.01		97.917	27		
	2.382		0.151		99.161		98.068	29		
	2.237		0.145		99.306		98.213	31		
	1.913		0.324		99.63		98.537	33		
	1.194		0.719		100.349		99.256	35		
	0.795		0.399		100.748		99.655	37		
	0.723		0.072		100.82		99.727	39		
	0.675		0.048		100.868		99.775	41		
	0.635		0.04		100.908		99.815	43		RH Rock ℄
		1.377		0.742	100.166		99.073	64		(As #2)
		[illegible]	[illegible]	[illegible]	[illegible]					
0.166			0.166		0.166	Differences				

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage
TOKELAU ISLANDS
(E)

Instr. NK-2
Type of staff ANGLO
Conditions Warm, Scattered cloud.

Observer Skinner
Booker Matulino
Date 6 May 85
Checked Skinner

Job File
Sheet
File Ref

Field Sheet No. 7
of 13 sheets
Plan Ref F

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.537					100.00	-1.04	98.96	∅	59.4∅ m/h	mag
	0.917		0.42		100.42		99.38	18		LH Rock ℄
	1.652			0.735	99.685		98.645	24.3		Edge shelf.
	2.276			0.624	99.061		98.021	27		
	2.163		0.113		99.174		98.134	29		
	2.121		0.042		99.216		98.176	31		
	1.584		0.537		99.753		98.713	33		
	0.965		0.619		100.372		99.332	35		
	0.678		0.287		100.659		99.619	37		
	0.476		0.202		100.861		99.821	39		
	0.525			0.049	100.812		99.772	41		
	0.568			0.043	100.769		99.729	43		RH Rock ℄
		1.320		0.752	100.017		98.977	64.		(AS FOR #2)
0.917		0.917			0.917	Differences				

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job: Atafu Reef Passage TOKELAU IS. (G)

Instr. NK-2
Type of staff 'ANGLO'
Conditions Warm Scattered cloud

Observer Skinner
Booker Matolina
Date 6 Mar 85
Checked Skinner

Job File
Sheet
File Ref

Field Sheet No. 8 of 13 sheets
Plan Ref (G)

Ministry of Works and Development

Levelling Sheet

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.291					100.00	-1.128	98.872	ϕ	59.4ϕ mp	mag
	0.805		0.486		100.486		99.358	18		LH Rock &
	1.344			0.539	99.947		98.819	23.9		Edge shelf.
	2.078			0.734	99.213		98.085	27		
	2.088			0.01	99.203		98.075	29		
	1.990		0.098		99.301		98.173	31		
	1.570		0.42		99.721		98.593	33		
	1.054		0.516		100.237		99.109	35		
	0.819		0.235		100.472		99.344	37		
	0.723		0.096		100.568		99.44	39		
	0.730			0.007	100.561		99.433	41		
	0.685		0.045		100.606		99.478	43		
		1.340		0.655	99.951		98.823	64		
	0.049		0.049		0.049	Differences				

Please return to nearest office of Ministry of Works and Development

Job: Atafu Reef Passage
Tokelau Islands
(H)

Instr. NK-2
Type of staff: ANGLO
Conditions: Warm Scattered cloud

Observer: Skinner
Booker: Matalina
Date: 6 Mar 85
Checked: Skinner

Job File
Sheet
File Ref

Field Sheet No. 9
of 13 sheets
Plan Ref H

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
0.999					100.00	-1.018	98.982	ϕ	59.40mp	mag
	0.919		0.08		101.08		99.062	18		LH Rock ℄
	1.415			0.496	100.584		98.566	22.8		Edge shelf
	2.025			0.61	99.974		97.956	25		
	2.134			0.109	99.865		97.847	25		
	2.083		0.051		99.916		97.898	29		
	1.879		0.204		100.12		98.102	31		
	1.695		0.184		100.304		98.286	33		
	0.675		1.02		101.324		99.306	36		
	0.941			0.266	101.058		99.04	37		
	0.815		0.126		101.184		99.166	39		
	0.938			0.123	101.061		99.043	41		
	0.905		0.033		101.094		99.076	43		RH Rock ℄
		1.320		0.415	100.679		98.661	64		(As for #2).
0.321			0.321		0.321	Differences				

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job: Atafu Reef Passage Tokelau Island (1)	Instr. NK-2 Type of staff: ANGLO Conditions: Warm scattered cloud	Observer: Skinner Booker: Matolina Date: 6 Mar 85 Checked: Skinner	Job File Sheet File Ref
			Field Sheet No. 10 of 13 sheets Plan Ref (1)

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.502					100.00	-1.143	98.857	∅	59.4∅m/	mag
	1.184		0.318		100.318		99.175	18		LH Rock ℄
	2.295			1.111	99.207		98.064	25		
	2.332			0.037	99.170		98.027	27		
	2.341			0.009	99.161		98.018	29		
	2.230		0.111		99.272		98.129	31		
	1.945		0.285		99.557		98.414	33		
	1.542		0.403		99.960		98.817	35		
	1.503		0.039		99.999		98.856	37		
	1.418		0.085		100.084		98.941	39		
	1.368		0.05		100.134		98.991	41		
	1.470			0.102	100.032		98.889	43		RH Rock ℄
		1.440			100.062		98.919	64		(As For #2)

Differences

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job: Atafu Reef Passage TOKELAU ISLAND (1)

Instr.: NK-2
Type of staff: ANGLO
Conditions: WARM CLEAR

Observer: Skinner
Booker: Matulino
Date: 6 Mar 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 11
of 13 sheets
Plan Ref: J

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.492					100.00	-1.276	98.724	ϕ	59.4ϕmh	mag
	1.505			0.013	99.987		98.711	18		LH Rock ℄
	1.495		0.010		99.997		98.721	21.5		
	2.241			0.746	99.251		97.975	23		
	2.252			0.011	99.24		97.964	25		
	2.275			0.023	99.217		97.941	27		
	2.250		0.025		99.242		97.966	29		
	2.035		0.215		99.457		98.181	31		
	1.933		0.102		99.559		98.283	33		
	1.515		0.418		99.977		98.701	35		
	1.510		0.005		99.982		98.706	37		
	1.425		0.085		100.067		98.795	39		
	1.410		0.015		100.082		98.806	41		
	1.445			0.035	100.047		98.771	43		
		1.505		0.060	99.987		98.711	64		(As For #2)

Differences

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job Atafu Reef Passage Tokelau Island (K)	Instr. NK-2 Type of staff 'Anglo' Conditions HOT CLEAR	Observer Skinner Booker Matolino Date 6 Mar 85 Checked Skinner	Job File Sheet File Ref	Field Sheet No. 12 of 13 sheets Plan Ref K

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.462					100.00	-1.316	98.684	ϕ	59.4ϕ m	mag. No Rock Piles
	1.431		0.031		100.031		98.715	3		
	1.445			0.014	100.017		98.701	6		
	1.344		0.101		100.118		98.802	9		
	1.332		0.012		100.13		98.814	12		
	1.314		0.018		100.148		98.832	15		
	1.322			0.008	100.14		98.824	18		
	1.335			0.013	100.127		98.811	21		
	2.222			0.887	99.24		97.924	23		
	2.565			0.343	98.897		97.581	25		
	2.424		0.141		99.038		97.722	27		
	2.405		0.019		99.057		97.741	29		
	2.328		0.077		99.134		97.818	31		
	2.175		0.153		99.287		97.971	33		
	1.505		0.67		99.957		98.641	35		
	1.348		0.157		100.114		98.798	38		
	1.385			0.037	100.077		98.761	41		
	1.425			0.04	100.037		98.721	43		
	1.395		0.03		100.067		98.751	45		
	1.382		0.013		100.08		98.764	47		
		1.440		0.058	100.022		98.706	64.		
	[illegible]		[illegible]		0.022	Differences				

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job: Atafu Reef Passage
Takelau Islands
L

Instr.: NK-2
Type of staff: ANGLO
Conditions: HOT CLEAR

Observer: Skinner
Booker: Matolino
Date: 6 Mar 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 13 of 13 sheets
Plan Ref: C

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.485					100.00	-1.378	98.622	0	59.40 M	mag.
	1.545			0.06	99.94		98.562	5		
	1.477		0.068		100.08		98.63	10		
	1.532			0.055	99.953		98.575	15		
	1.558			0.026	99.927		98.549	20		
	2.790			1.232	98.695		97.317	27.4		
	1.535		1.255		99.95		98.572	34		
	1.497		0.038		99.988		98.61	40		
	1.501			0.004	99.984		98.606	45		
	1.575			0.074	99.91		98.532	50		
		1.633		0.058	99.852		98.474	64		
1.485		1.633	1.341	1.509	98.622					
	0.148		0.148		0.148	Differences				

Ministry of Works and Development

Levelling Sheet

Serial	Cross Section	Calculation	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
1	A - B	$\frac{3.96\ m^2 + 4.8\ m^2}{2} \times 10\ m$	$43.8\ m^3$	Nil	$43.8\ m^3$
2	B - C	$\frac{4.8\ m^2 + 6.3\ m^2}{2} \times 10\ m$	$55.5\ m^3$	Nil	$55.5\ m^3$
3	C - D	$\frac{6.3\ m^2 + 2.63\ m^2}{2} \times 10\ m$	$44.65\ m^3$	Nil	$44.65\ m^3$
4	D - E	$\frac{2.63\ m^2 + 6.18\ m^2}{2} \times 10\ m$	$44.05\ m^3$	Nil	$44.05\ m^3$
5	E - F	$\frac{6.18\ m^2 + 9.52\ m^2}{2} \times 10\ m$	$78.5\ m^3$	Nil	$78.5\ m^3$
6	F - G	$\frac{9.52\ m^2 + 8.41\ m^2}{2} \times 10\ m$	$89.65\ m^3$	Nil	$89.65\ m^3$
7	G - H	$\frac{8.41\ m^2 + 5.97\ m^2}{2} \times 10\ m$	$71.9\ m^3$	Nil	$71.9\ m^3$
8	H - I	$\frac{5.97\ m^2 + 6.04\ m^2}{2} \times 10\ m$	$60.05\ m^3$	Nil	$60.05\ m^3$

Serial	Cross Section	Calculation	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
9	I - J	$\frac{2.43\ m^2 + 2.04\ m^2}{2} \times 10\ m$	22.35 m^3		71.0 m^3
		$\frac{3.61\ m^2 + 6.12\ m^2}{2} \times 10\ m$		48.65 m^3	
10	J - K	$\frac{8.16\ m^2 + 18.27\ m^2}{2} \times 10\ m$	Nil	132.15 m^3	132.15 m^3
11	K - L	$\frac{18.27\ m^2 + 20.52\ m^2}{2} \times 10\ m$	Nil	193.95 m^3	193.95 m^3
12	L - M	$\frac{20.52\ m^2 + 21.42\ m^2}{2} \times 10\ m$	Nil	209.7 m^3	209.7 m^3
13	M - N	$\frac{21.42\ m^2 + 15.42\ m^2}{2} \times 10\ m$	Nil	184.2 m^3	184.2 m^3
14	N - O	$\frac{15.42\ m^2 + 10.48\ m^2}{2} \times 10\ m$	Nil	129.5 m^3	129.5 m^3
15	TOTAL		510.45^3	898.15 m^3	1408.6 m^3

ANNEX J TO
TOKELAU RECON REPORT
DATED 10 MAY 85

NUKUNONU REEF CHANNEL

Appendices to this Annex are the technical details of data obtained during the surveying of the channel.

Appendices: 1. Plan View

2. Detailed Cross-Sections

3. Survey Sheets

4. Volume Calculations

Note: Appendices 1, 2, are not attached, but are separate to this Report.

APPENDIX 3 TO
ANNEX J TO
TOKELAU RECON
REPORT
DATED 10 MAY 85

Please return to nearest office of Ministry of Works and Development

Ministry of Works and Development

Levelling Sheet

Job Nukunonu Reef Passage Tokelau Island	Instr. NK-2 / Type of staff 'Anglo' / Conditions Hot CLEAR	Observer Skinner / Booker Skinner / Date 28th Feb 85 / Checked	Job File / Sheet / File Ref
Field Sheet No. 1 of 1 sheets / Plan Ref			

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
										Distance = 24 m
										DATUM = Corner RHS FOOTPATH.
A							98.39	∅		Mag Bg to Row A
							98.375	12	Offset 3m	End of Deep channel.
							97.335	29		
							98.075	48		$\overline{AB}$, $\overline{BC}$, $\overline{CD}$ = 30 m ea
B							98.335	∅		
							97.535	10		
							97.205	25		
							98.375	39		
C							98.125	∅		
							97.385	9		
							96.805	20		
							97.335	30		
D							98.435	∅		
							97.835	7		Low tide 98.2
							96.625	13.5		High tide 99.889
							97.705.	20.		

Differences

APPENDIX 4 TO
ANNEX J TO
TOKELAU RECON REPORT
DATED 10 MAY 85

NUKUNONU - VOLUME CALCULATIONS

Serial	Cross Section	Calculations	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
1	A - B	$\frac{18.22\ m^2 + 18.52\ m^2}{2} \times 30\ m$	551.1 m^3	Nil	551.1 m^3
2	B - C	$\frac{18.52\ m^2 + 10.53\ m^2}{2} \times 30\ m$	435.75 m^3	Nil	435.75 m^3
3	C - D	$\frac{10.53\ m^2 + 12.8\ m^2}{2} \times 30\ m$	280.95 m^3	Nil	280.95 m^3
4	TOTAL		1267.8 m^3	Nil	1267.8 m^3

ANNEX K TO
TOKELAU RECON REPORT
DATED 10 MAY 85

FAKAOFO REEF CHANNEL

Appendices to this Annex are the technical details of data obtained during the surveying of the channel.

Appendices: 1. Plan View

2. 3D Plan View

3. Detailed Cross-Sections

4. Longitudinal Cross-Section

5. Survey Sheets

6. Centre-Line Levels

7. Volume Calculations

Note: Appendices 1, 2, 3 and 4 are not attached, but are separate to this Report.

APPENDIX 5 TO
ANNEX K TO
TOKERLAU RECON
REPORT
DATED 10 MAY 85

Please return to nearest office of Ministry of Works and Development

Job Fakaofo Reef Passage Tokelau Is.	Instr. NK-2 Type of staff Anglo Conditions Warm Clear 32°C	Observer Skinner Booker Skinner Date 13 Mar 85 Checked	Job File Sheet File Ref
			Field Sheet No. 1 of 14 sheets Plan Ref RHS Linear

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.075					100.00			11.5	FM DATUM	Level to DATUM = 11.5m
A	level 1.30			0.225	99.775			0	to level	DATUM = Corner of Copra shed RH Front
B	1.41			0.11	99.665			10	50.30m	
C	1.27		0.14		99.405			20	43.20m	RH side on RHS of cone mooring block
D	1.23		0.04		99.845			30		
E	1.155		0.075		99.92			40		
F	1.072		0.083		100.003			50		
G	1.174			0.102	99.901			60		
H	1.325			0.151	99.75			70		
I	1.752			0.427	99.323			80		
J	1.864			0.112	99.211			90		
K	1.823		0.041		99.252			100		
L	1.88			0.057	99.195			110		
M	1.835		0.045		99.24			120		
N	2.035			0.20	99.04			130		Edge of cone block
O	2.115			0.08	98.96			140		
P					98.8			150		
Q					99.7			170		
R					97.4			190		All on sheet #2 A
S					96.14			200		High tide = 0.05 m above X 99.944
										Low tide = 1.00 m below X 98.894
										X Height = 99.894 @ RH corner of wharf

Differences

Ministry of Works and Development

Levelling Sheets

Please return to nearest office of Ministry of Works and Development

Ministry of Works and Development — Levelling Sheet

Job: Fakaofo Reef Passage, Tokelau Is	Instr.: NK-2 Type of staff: Anab Conditions: Warm, Cloudy 82°F	Observer: Skinner Booker: Skinner Date: 13 May 85 Checked:	Job File: Sheet: File Ref:	Field Sheet No. 2 of 14 sheets Plan Ref: (A?)

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.19							99.775	ϕ	2530 mh	
	1.112		0.078				99.853	2		
	1.071		0.041				99.894	2.7		Edge channel RHS
	1.852			0.781			99.113	4		
	1.855			0.003			99.11	6		
	1.90			0.052			99.058	8		
	1.973			0.066			98.992	10		
	2.033			0.06			98.932	12		
	2.284			0.251			98.681	14		
	1.825		0.459				99.14	16		
		1.018	0.807				99.947	18		Edge channel LHS Sea wall 0.1m away.
[illegible]		[illegible]	[illegible]							
	0.172					Differences				

P.W. 709

Please return to nearest office of Ministry of Works and Development

Ministry of Works and Development

Levelling Sheet

Job FAKAOFO REEF PASSAGE TOKELAU IS	Instr. NK-2 Type of staff "ANHO" Conditions WARM CLOUDY 32°C	Observer SKINNER Booker MATULINO Date 13 MAR 85 Checked SKINNER	Job File Sheet File Ref
			Field Sheet No. 3 of 14 sheets Plan Ref ROW B

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.39					100.00	-0.335	99.665	Ø	272Ø uh	
	1.231		0.159		100.159		99.824	2		
	1.164		0.067		100.226		99.891	4		
	1.195			0.031	100.195		99.86	5.3		RH CHANNEL EDGE
	2.557			1.362	98.833		98.498	6		
	2.547		0.01		98.843		98.508	8		
	2.538		0.009		98.852		98.517	10		
	2.565			0.027	98.825		98.49	12		
	2.480		0.085		98.91		98.575	14		
	2.453		0.027		98.937		98.602	16		
	2.280		0.17		99.11		98.775	16.3		LH CHANNEL EDGE
		1.324	0.956		100.066		99.731	18		

0.066 0.066 0.066 Differences

74095G—500pads/11/81MK

Survey Sheet No. 6 (19

P.W. 709

Ministry of Works and Development

Levelling Sheet

Job: Fakaofo Reef Passage, Tokelau Islands

Instr.: NK-2
Type of staff: ANGLO
Conditions: V Warm. Cloudy 32°C

Observer: Skinner
Booker: Matalina
Date: 13 May 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 4 of 14 sheets
Plan Ref: C.

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
2.002					100.00	-0.195	99.405	∅	272∅ m	
	1.112		0.890		100.89		100.295	2		
	1.090		0.022		101.11		100.317	4		
	1.068		0.022		101.132		100.439	6		
	1.070			0.002	101.129		100.437	7.4		RH edge Channel.
	2.503			1.433	99.696		98.904	8		
	2.772			0.289	99.407		98.615	10		
	2.825			0.033	99.374		98.582	12		
	3.060			0.235	99.139		98.347	14		
	3.185			0.125	99.014		98.222	16		
	2.415				99.784		98.992	17.5		LH channel edge.
		2.435		0.02	99.764		98.972	19.		

[illegible]		[illegible]	[illegible]	[illegible]	99 [illegible]
0.433		0.433			0.435

Differences

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.259					100.00	-0.155	99.845	ϕ	272ϕ·m	
	1.535			0.276	99.724		99.569	2		
	1.150		0.385		100.109		99.954	4		
	1.405			0.255	99.854		99.699	6		
	1.435			0.03	99.824		99.669	7.6		
	2.443			1.008	98.816		98.661	8		
	2.614			0.171	98.645		98.49	10		
	2.695			0.081	98.564		98.409	12		
	2.639		0.056		98.62		98.465	14		
	2.565		0.074		98.694		98.539	16		
	2.230		0.335		99.029		98.874	18		
		1.162	1.068		100.097		99.942	20		

Ministry of Works and Development

Levelling Sheet

74095G–500pads/11/81MK

Please return to nearest office of Ministry of Works and Development

P.W. 709

Ministry of Works and Development

Levelling Sheet

Job: FAKAOFO REEF PASSAGE TOKELAU IS

Instr. NK-2
Type of staff "ANGLO"
Conditions HOT CLOUDY

Observer SKINNER
Booker MATULINO
Date 13 MAR 85
Checked SKINNER

Job File
Sheet
File Ref

Field Sheet No. 6 of 14 sheets
Plan Ref ROWE

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.324					100.00	-0.08	99.92	ϕ	2720m	
	1.513			0.189	99.811		99.731	2		
	1.520			0.007	99.804		99.724	4		
	1.675			0.155	99.649		99.569	6		
	1.748			0.073	99.576		99.496	7.6		
	2.585			0.837	98.736		98.659	8		
	2.875			0.29	98.449		98.369	10		
	2.942			0.067	98.382		98.302	12		
	2.975			0.033	98.349		98.269	14		
	2.950		0.025		98.374		98.294	16		
	2.875		0.055		98.429		98.349	18		
	2.855		0.04		98.469		98.389	19		
		1.618	1.237		99.706		99.626	21		
	[illegible]		[illegible]		[illegible] Differences					

74095G–500pads/11/81MK

Survey Sheet No. 6 (19

Please return to nearest office of Ministry of Works and Development

Job: Fakaofo Reef Passage, Takelau Is (F)

Instr.: NK-2
Type of staff: Analo
Conditions: Hot, cloudy

Observer: Skinner
Booker: Matalina
Date: 13 Mar 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 7 of 14 sheets
Plan Ref: (F)

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.315					100.00	+0.003	100.003	∅	2720∅m	
	1.304		0.011		100.011		100.014	2		
	1.325			0.021	99.99		99.993	4		
	1.278		0.047		100.037		100.04	6		
	1.403			0.125	99.912		99.915	8		
	1.762			0.359	99.553		99.556	8.8		
	2.938			1.176	98.377		98.38	10		
	3.035			0.097	98.28		98.283	12		
	3.147			0.112	98.168		98.171	14		
	3.135		0.012		98.18		98.183	16		
	3.075		0.06		98.24		98.243	18		
	1.775		1.30		99.54		99.543	19.5		
		1.705	0.07		99.61		99.613	21		
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	Differences				
0.39			0.39		0.39					

Ministry of Works and Development

Levelling Sheet

Please return to nearest office of Ministry of Works and Development

Job: Fakaofo Reef Passage Tokelau Island (G)

Instr.: Nk-2
Type of staff: Anglo
Conditions: Hot cloudy

Observer: Skinner
Booker: Matulino
Date: 13 Mar 85
Checked: Skinner

Job File:
Sheet:
File Ref:

Field Sheet No. 8 of 14 sheets
Plan Ref: (C)

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.316						-0.099	99.901	∅	272∅ m	
	1.324			0.008			99.893	2		
	1.582			0.258			99.635	4		
	1.507		0.075				99.71	6		
	1.623			0.116			99.594	8		
	1.688			0.065			99.529	8.9		
	2.947			1.259			98.27	10		
	2.907		0.04				98.31	12		
	3.108			0.201			98.109	14		
	3.095		0.013				98.122	16		
	3.110			0.015			98.107	18		
	2.512		0.598				98.705	18.9		
		1.540	0.972				99.677	21		
[illegible]		1.540	[illegible]	[illegible]	[illegible]					
	0.224		0.224		0.224	Differences				

Ministry of Works and Development

Levelling Sheet

P.W. 709

Please return to nearest office of Ministry of Works and Development

Job FAKAOFO REEF PASSAGE TOKELAU IS	Instr. NK-2 Type of staff "ANGLO" Conditions HOT CLOUDY	Observer SKINNER Booker MATULINO Date 13 MAR 85 Checked SKINNER	Job File Sheet File Ref
Field Sheet No. 9 of 14 sheets Plan Ref ROW H			

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.302					100.00	-0.25	99.75	∅	272∅m	
	1.331			0.029	99.971		99.721	2		
	1.495			0.164	99.807		99.557	4		
	1.667			0.172	99.635		99.385	6		
	1.713			0.046	99.589		99.339	8		
	2.085			0.372	99.217		98.967	10		
	2.887			0.802	98.415		98.165	12		
	2.825		0.062		98.477		98.227	14		
	2.918			0.093	98.384		98.134	16		
	3.062			0.144	98.24		97.99	18		
	2.665		0.397		98.637		98.387	20		
		1.520	1.145		99.782		99.532	22		

0.218 0.218 0.218 Differences

Ministry of Works and Development

Levelling Sheet

74095G–500pads/11/81MK

Survey Sheet No. 6 (19

Please return to nearest office of Ministry of Works and Development

P.W. 709

Job FAKAOFO REEF PASSAGE TOKELAU IS	Instr. NK-2 Type of staff "ANGLO" Conditions WARM CLOUDY	Observer SKINNER Booker MATULINO Date 14 MAR 85 Checked SKINNER	Job File Sheet File Ref
			Field Sheet No. 10 of 14 sheets Plan Ref ROW I

Back sight	Intermediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1·409					100-00	-0·677	99·323	∅	272∅	
	1,285		0·124		100·124		99·447	2		
	1·248		0·037		100·161		99·484	4		
	1·486			0·238	99·923		99·246	6		
	1·233		0·253		100·176		99·499	8		
	1·518			0·285	99·891		99·214	10		
	1·515		0·003		99·894		99·217	12		
	1·654			0·139	99·755		99·078	13		
	2,129			0·475	99·28		98·603	14		
	2,373			0·244	99·036		98·359	16		
	2,395			0·022	99·014		98·337	18		
	2·362		0·033		99·047		98·37	20		
	2,204		0·158		99·205		98·528	22		
	1·645		0·559		99·764		99·087	23·6		
	1·537		0·108		99·872		99·195	25		
	1,485		0·052		99·924		99·247	27		
		1·320	0·165		100·089		99·412	30		

0·089 | 0·089 | 0·089 Differences

Ministry of Works and Development

Levelling Sheet

74095G–500pads/11/81MK

Survey Sheet No. 6 (19

Please return to nearest office of Ministry of Works and Development

P.W. 709

Ministry of Works and Development

Levelling Sheet

Job: FAKAOFO REEF PASSAGE
TOKELAU IS

Instr.: NK-2
Type of staff: "ANGLO"
Conditions: V. WARM CLOUDY

Observer: SKINNER
Booker: MATULINO
Date: 14 MAR 85
Checked: SKINNER

Job File:
Sheet:
File Ref:

Field Sheet No. 11 of 14 sheets
Plan Ref: ROW J

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.467					100.000	0.789	99.211	Ø	272Øm	
	1.515			0.048	99.952		99.163	2		
	1.369		0.146		100.098		99.309	4		
	1.419			0.05	100.048		99.259	6		
	1.423			0.004	100.044		99.255	8		
	1.467			0.044	100.00		99.211	10		
	1.618			0.151	99.849		99.06	12		
	1.714			0.096	99.753		98.964	14		
	2.262			0.548	99.205		98.416	16		
	2.374			0.112	99.093		98.304	18		
	2.395			0.021	99.072		98.283	20		
	2.347		0.048		99.12		98.331	22		
	1.637		0.71		99.83		99.041	24		
	1.535		0.102		99.932		99.43	26		
	1.540			0.005	99.927		99.138	28		
	1.515		0.025		99.952		99.163	30		
		1.456	0.059		100.011		99.222	32		
	0.011		0.011		0.011	Differences				

740956—500pads/11/81MK

Survey Sheet No. 6 (19..

Ministry of Works and Development

Levelling Sheet

1.167					100.00	-0.748	99.252	∅	272∅m	
	1.104		0.063		100.063		99.315	2		
	1.007		0.097		100.16		99.412	4		
	1.014			0.007	100.153		99.405	6		
	0.968		0.046		100.199		99.451	8		
	1.034			0.066	100.133		99.385	10		
	1.530			0.496	99.637		98.889	12		
	1.942			0.412	99.225		98.477	14		
	2.137			0.195	99.03		98.282	16		
	2.335			0.198	98.832		98.084	18		
	2.395			0.06	98.772		98.024	20		
	2.498			0.103	98.669		97.921	22		
	2.487		0.011		98.68		97.932	24		
	1.724		0.763		99.443		98.695	26		
	1.624		0.1		99.543		98.795	28		
	1.560		0.064		99.607		98.859	30		
	1.248		0.312		99.919		99.171	32		
		0.953	0.295		100.214		99.466	34		

Differences

74095G—500pads/11/81MK

Please return to nearest office of Ministry of Works and Development

P.W. 709

Ministry of Works and Development

Levelling Sheet

Job FAKAOFO REEF PASSAGE
TOKELAU IS

Instr. NK-2
Type of staff "ANGLO"
Conditions HOT CLEAR

Observer SKINNER
Booker MATULINO
Date 13 MAR 85
Checked SKINNER

Job File
Sheet
File Ref

Field Sheet No. 13
of 14 sheets
Plan Ref ROW L

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.416					100.00	-0.805	99.195	Ø	272Øm	
	1.362		0.054		100.054		99.249	2		
	1.454			0.092	99.962		99.157	4		
	1.436		0.018		99.98		99.175	6		
	1.046		0.39		100.37		99.565	8		
	1.617			0.571	99.799		98.994	10		
	1.838			0.221	99.578		98.773	12		
	2.048			0.21	99.368		98.563	14.4		
	2.496			0.448	98.92		98.115	16		
	2.588			0.092	98.828		98.023	18		
	2.641			0.053	98.775		97.97	20		
	2.733			0.092	98.683		97.878	22		
	2.826			0.093	98.59		97.785	24		
	2.282		0.544		99.134		98.329	26		
	2.209		0.073		99.207		98.402	28		
	1.548		0.661		99.868		99.063	30		
	1.264		0.284		100.152		99.347	32		
	1.149	1.149	0.115		100.267		99.462	34		
1.416		1.149	2.131	1.872	99.195					
	0.267		0.259		0.267	Differences				

74095G—500pads/11/81MK

Survey Sheet No. 6 (1970)

Please return to nearest office of Ministry of Works and Development

Job Fakaofo Reef Passage
Tokelau Islands
(m)

Instr. NK-2
Type of staff Anglo
Conditions HOT CLOUDY

Observer Skinner
Booker Metalino
Date 13 Mar 85
Checked Skinner

Job File
Sheet
File Ref

Field Sheet No. 14
of 14 sheets
Plan Ref (m)

Back sight	Inter-mediate	Fore sight	Rise	Fall	Reduced Level	Corr.	Adjusted Level	Distance (m)	Bearing / Offset	Remarks
1.281					100.00	-0.76	99.24	∅	272∅m	
	1.253			0.002	99.998		99.238	2		
	1.322			0.069	99.929		99.169	4		
	1.369			0.047	99.882		99.122	6		
	1.444			0.075	99.807		99.047	8		
	1.431		0.013		99.82		99.06	10		
	1.302		0.129		99.949		99.189	12		
	1.703			0.401	99.548		98.788	14		
	1.935			0.232	99.316		98.556	16		
	2.379			0.444	98.872		98.112	18		
	2.555			0.176	98.696		97.936	20		
	2.662			0.107	98.589		97.829	22		
	2.780			0.118	98.171		97.711	24		
	2.65		0.13				97.841	28.6		
	1.948			0.702			98.543	31		
		1.920	0.28				98.823	49.9		
1.281		1.920	1.704	2.373	99.24					
0.669		0.669			0.669	Differences				

Ministry of Works and Development

Levelling Sheet

FAKAOFO REEF CHANNEL

CENTRE - LINE LEVELS

Serial	Cross-Section	Centre Line RL
(a)	(b)	(c)
1	A	98.992
2	B	98.49
3	C	98.582
4	D	98.437
5	E	98.294
6	F	98.171
7	G	98.109
8	H	98.134
9	I	98.337
10	J	98.294
11	K	98.054
12	L	97.97
13	M	97.883
14	N	97.75
15	O	97.52
16	P	97.3
17	Q	97.0
18	X	96.76

FAKAOFO - VOLUME CALCULATIONS

Serial	Cross Section	Calculation	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
1	A - B	$\frac{18.15\ m^2 + 9.4\ m^2}{2} \times 10\ m$	$140.75\ m^3$	Nil	$140.75\ m^3$
2	B - C	$\frac{9.4\ m^2 + 6.33\ m^2}{2} \times 10\ m$	$78.65\ m^3$	Nil	$78.65\ m^3$
3	C - D	$\frac{6.33\ m^2 + 8.93\ m^2}{2} \times 10\ m$	$76.3\ m^3$	Nil	$76.3\ m^3$
4	D - E	$\frac{8.93\ m^2 + 8.36\ m^2}{2} \times 10\ m$	$86.45\ m^3$	Nil	$86.45\ m^3$
5	E - F	$\frac{8.36\ m^2 + 4.55\ m^2}{2} \times 10\ m$	$64.55\ m^3$	Nil	$64.55\ m^3$
6	F - G	$\frac{4.55\ m^2 + 4.28\ m^2}{2} \times 10\ m$	$44.15\ m^3$	Nil	$44.15\ m^3$
7	G - H	$\frac{4.28\ m^2 + 6.2\ m^2}{2} \times 10\ m$	$52.4\ m^3$	Nil	$52.4\ m^3$
8	H - I	$\frac{6.2\ m^2 + 12.44\ m^2}{2} \times 10\ m$	$93.1\ m^3$	Nil	$93.1\ m^3$

Serial	Cross Section	Calculation	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
9	I - J	$\frac{8.84\ m^2 + 8.24\ m^2}{2} \times 10\ m$	85.3 m^3		142.6 m^3
		$\frac{3.6\ m^2 + 7.86\ m^2}{2} \times 10\ m$		57.3 m^3	
10	J - K	$\frac{8.24\ m^2 + 6.89\ m^2}{2} \times 10\ m$	75.65 m^3		166.35 m^3
		$\frac{7.86\ m^2 + 10.28\ m^2}{2} \times 10\ m$		90.7 m^3	
11	K - L	$\frac{6.89\ m^2 + 7.61\ m^2}{2} \times 10\ m$	72.5 m^3		179.85 m^3
		$\frac{10.28\ m^2 + 11.19\ m^2}{2} \times 10\ m$		107.35 m^3	
12	L - M	$\frac{7.61\ m^2 + 5.54\ m^2}{2} \times 10\ m$	65.75 m^3		179.35 m^3
		$\frac{11.19\ m^2 + 11.53\ m^2}{2} \times 10\ m$		113.6 m^3	
13	M - N	$\frac{5.54\ m^2 + 1.18\ m^2}{2} \times 10\ m$	33.6 m^3		159.15 m^3
		$\frac{11.53\ m^2 + 13.58\ m^2}{2} \times 10\ m$		125.55 m^3	
14	N - O	$\frac{14.76\ m^2 + 22.88\ m^2}{2} \times 10\ m$	Nil	188.2 m^3	188.2 m^3

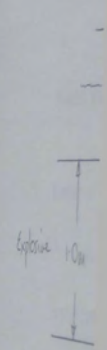
Serial	Cross Section	Calculation	Fines	Rock (Blasting Req)	Total Volume
(a)	(b)	(c)	(d)	(e)	(f)
15	O - P	$\frac{22.88\ m^2 + 18.37\ m^2}{2} \times 10\ m$	Nil	206.25 m^3	206.25 m^3
16	P - Q	$\frac{18.37\ m^2 + 20.64\ m^2}{2} \times 20\ m$	Nil	390.1 m^3	390.1 m^3
17	Q - X	$\frac{20.64\ m^2 + 14.5\ m^2}{2} \times 10\ m$	Nil	175.7 m^3	175.7 m^3
18	TOTAL		969.15 m^3	1454.75 m^3	2423.9 m^3

EX

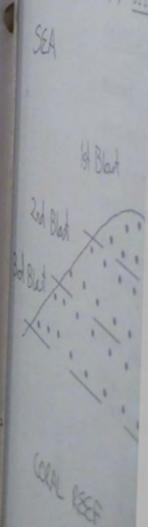
1. The following
explosives and associat
Atafu and Fakaofo:

a. Drilling
determine
completed
However,
pattern i

(1) Bore



(2) Dril



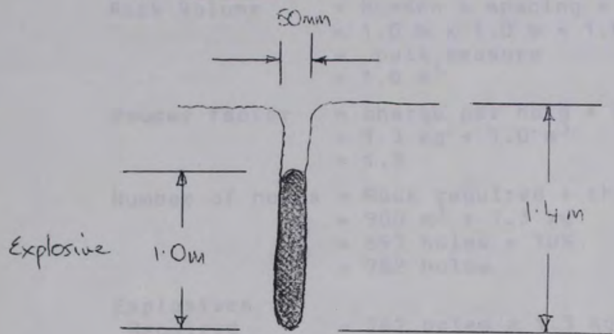
ANNEX L TO
TOKELAU RECON REPORT
DATED 10 MAY 85

EXPLOSIVE CALCULATIONS

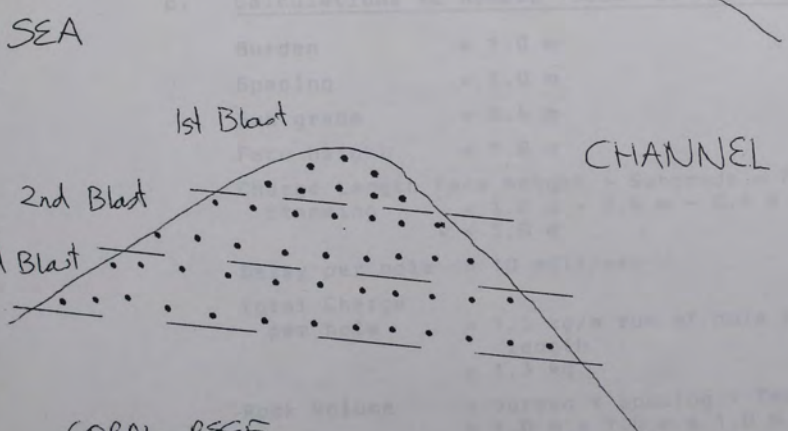
1. The following is an assessment of type and quantity of explosives and associated equipment required for the task at Atafu and Fakaofo:

a. Drilling Pattern. This can only be effectively determined once test drills and blasts have been completed insitu at Atafu and Fakaofo respectively. However, a suggested borehole depth and drilling pattern is as follows:

(1) Borehole.



(2) Drilling Pattern.



/b. Calculations

b. **Calculations to Remove 900 m^3 at Atafu.**

Burden	= 1.0 m
Spacing	= 1.0 m
Sub grade	= 0.4 m
Final stemming	= 0.4 m
Face height	= 1.0 m
Charge Length Face height + Subgrade - Final Stemming	= 1.0 m + 0.4 m - 0.4 m = 1.0 m
Delay per hole	= 10 mili/sec
Total charge per hole	= 1.3 kg/m run of hole x charge length = 1.3 kg
Rock Volume	= burden x spacing x face height = 1.0 m x 1.0 m x 1.0 m = bulk measure = 1.0 m^3
Powder factor	= charge per hold ÷ bulk measure = 1.3 kg ÷ 1.0 m^3 = 1.3
Number of holes	= Rock required ÷ charge per hole = 900 m^3 ÷ 1.3 kg = 693 holes + 10% = 762 holes
Explosives Required	= 762 holes x 1.3 kg = 990.6 kg = 990.6 ÷ 0.676 gms = 1466 carts + 10% = 1613 carts

c. **Calculations to Remove 1500m^3 at Fakaofo.**

Burden	= 1.0 m
Spacing	= 1.0 m
Sub grade	= 0.4 m
Face height	= 1.0 m
Charge Length Face height + Subgrade - Final Stemming	= 1.0 m + 0.4 m - 0.4 m = 1.0 m
Delay per hole	= 10 mili/sec
Total Charge per hole	= 1.3 kg/m run of hole x charge length = 1.3 kg
Rock Volume	= burden x spacing x face height = 1.0 m x 1.0 m x 1.0 m = 1.0 m^3 bulk measure

/Powder

Powder Factor	= charge per hole ÷ bulk measure
	= 1.3 kg ÷ 1.0 m^3
	= 1.3
Number of holes	= Rock required ÷ charge per hole
	= 1500 m^3 ÷ 1.3 kg
	= 1154 holes + 1-%
	= 1269 holes
Explosives Required	= 1269 holes x 1.3 kg
	= 1649.7 kg
	= 1500.2 kg ÷ 0.676 gms
	= 2441 carts + 10%
	= 2685 carts

Total explosives required = 4298 carts in boxes of 37 carts, Molanite.

d. Flexicord Required. For ring main to charge:

Hole depth	= 1.4 m
Length of Card	= 2 x 1.4 m + tying off
	= 0.4 m + securing of explosives
	= 0.2 m
	= 3.4 m, say 3.5 m per hole

∴ Atafu (762 holes) = 2667 m
Fakaofo (1269 holes) = 4441.5 m

For ring mains: @ 1.5 m/hole

∴ Atafu (762 holes) = 1143 m
Fakaofo (1269 holes) = 1903.5 m

Totals:	Atafu	= 3810 m
	Fakaofo	= 6345 m
	Total	= 10155 m

e. Detonators Required.

@ 1 x det/blast

if 1 x blast = average of 25 holes
= 82 detonators

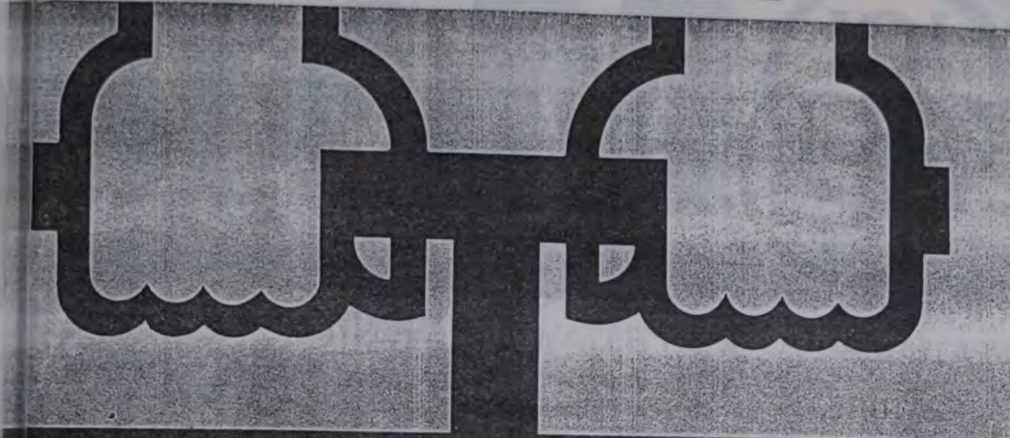
f. Detonating Relay Connectors Required.

@ a x DRC/5 holes = 407

g. It must be remembered that there is no readily available resupply available on Tokelau.

h. Shot firing cable = 600 m.

APPENDIX 1 TO
ANNEX L TO
TOKELAU RECON REPORT
DATED 10 MAY 85



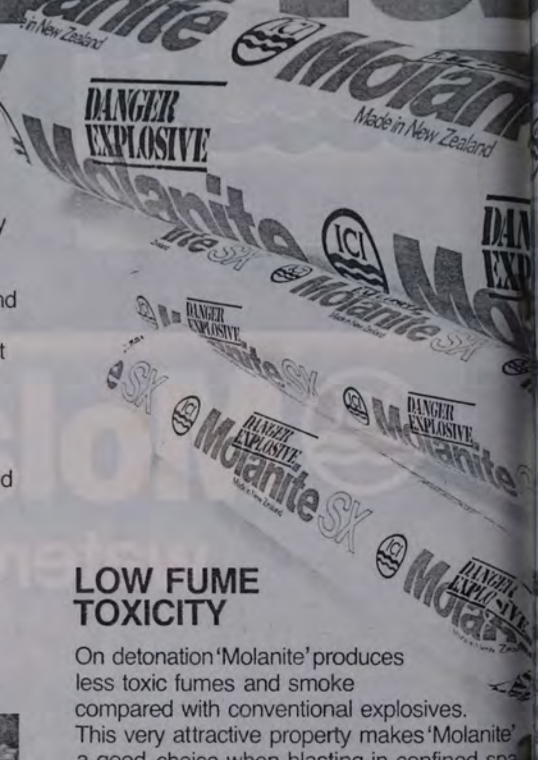
ICI

Molanite®

watergels

ICI New Zealand Limited Explosives Division

Mola



FEATURES

ICI has been manufacturing slurry explosives in New Zealand since 1968, and has shown a steady advance in technology and performance.
'Molanite' is a high strength detonator–sensitive slurry formulated from non-explosive ingredients and is designed to replace conventional gelatinous explosives in many blasting applications. The latest advance, automatic cartridging of the slurries, provides superior packaging, and accuracy of diameters and lengths.
The 'Molanite' range of products is designed to provide good storage qualities, ease of loading, and packaging to meet your needs.

OPERATOR COMFORT

The 'Molanite' range does not produce the headaches symptomatic of the nitro-glycerine explosives, and there are no fumes in storage.

'Molanite' loads easily

LOW FUME TOXICITY

On detonation 'Molanite' produces less toxic fumes and smoke compared with conventional explosives. This very attractive property makes 'Molanite' a good choice when blasting in confined spa

SAFETY

Whilst sensitive to a detonator 'Molanite' has a l sensitivity to mechanical impact than conventio explosives. Tests have also shown that when engulfed in a hot fire 'Molanite' will burn but it is unlikely to detonate.

Specialist packs

ite® watergels

WATER RESISTANCE

The firm gel structure of 'Molanite' has inherent water resistant properties which permit it to be loaded into water filled holes without detracting from its explosive properties. The new packaging material enhances this feature.

TECHNICAL ADVICE

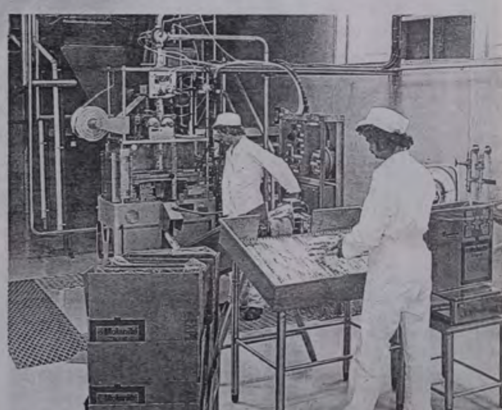
The 'Molanite' range of products is backed by ICI's team of experienced and qualified field staff for consulation on-site to ensure the most efficient use of the products in all blasting conditions.

...IMING

...e' in all grades and diameters can be reliably ...ne by a No. 8 detonator or a 10 gram per ...detonating cord e.g. 'Flexicord' or 'Redcord'. ...ver, where the ambient temperature is below ... a primer such as an 'Anzomex Booster' or ...ite' is strongly recommended.

...g with 'Flexicord'

Priming with detonator



Cartridging Machine

Factory

ICI powermasters at your command

ICI research and development is your guarantee of a dependable, powerful product range to optimise your blasting.

In keeping with the high standard of reliability of all ICI explosives, "Molanite" is subject to stringent quality control and testing. This extends from laboratory to on-the-job situations.

Service with safety is the guiding principle of ICI, world leaders in research and development of explosives and techniques for their application.

ICI "Molanite" is manufactured in New Zealand to satisfy a broad spectrum of specifically local requirements. It is always readily available; and it is backed up by a full technical advisory service which is freely available for blasting consultation.

Everything for blasting . . . anywhere in N.Z.

In addition to manufacture, sales and technical service, ICI supplies a full range of back-up accessories:
DETONATORS • DETONATING FUSE • IGNITER CORD • EXPLODERS • VIBRATION DETECTING EQUIPMENT
All products are available in continuous supply throughout New Zealand.

1. AN Gelatine Dynamite '95'
2. 'Molanite' large diameter
3. 'Molanite' SX
4. 'Exactex'
5. AN gelignite '60'
6. 'Plastergel'
7. 'Morcol'
8. 'Ajax'
9. 'L' series millisecond delay detonator
10. Half second delay detonator
11. Igniter cord connector
12. No 8 plain detonator
13. 'Anzomex' Booster M 250g
14. 'Anzomex' Booster Q 416g
15. 'Anzomex' Booster D 139g
16. 'Anzomex' Booster A 25g
17. 'Flexicord' detonating cord
18. No 8/1.8m aluminium electric detonator
19. No 6/1.8m copper electric detonator
20. No 8/1.8m submarine detonator
21. No 8 star/1.8m seismic detonator
22. 'Redcord' detonating cord
23. 'Metabel'
24. 'Selected Buff' safety fuse
25. 'Nitropril' ammonium nitrate
26. 'Amex'
27. Blasting powder
28. 'Aluminex'
29. 'Shearcord'
30. 'Trunkcord'
31. Electric lighter
32. Igniter cord fast
33. Detonating relay connector –
gold 35 m/s
green 45 m/s
blue 25 m/s
black 15 m/s

POWERMASTERS AT YOUR COMMAND

ICI Explosives

ICI New Zealand Limited, Box 900, Auckland New Zealand.

APPENDIX 2 TO
ANNEX L TO
TOKELAU RECON REPORT
DATED 10 MAY 85

advantages

ICI Molanite: a big advance
"MOLANITE" high strength detonator-sensitive slurry is formulated entirely from non-explosive ingredients and is designed to replace conventional gelatinous explosives in blasting applications.
"MOLANITE" is designed to slump into down holes to provide good coupling with the walls of the blast hole and to achieve a high loading density . . . important features in optimising the economics of a blasting operation!

Safety: high standards
Whilst sensitive to initiation by a detonator, "MOLANITE" unlike conventional nitro-glycerine explosives is not detonated by mechanical impact.
Tests have also shown, that when engulfed by a hot fire "MOLANITE" will burn with a strong intense flame but will not detonate.

Fume: less toxicity
On detonation "MOLANITE" produces less toxic fumes and smoke when compared with conventional explosive. This excellent property makes "MOLANITE" a good choice when blasting in a confined space as in shaft sinking or tunnelling.

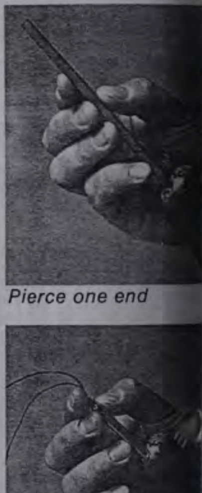
Priming: simple and reliable
"MOLANITE" can be reliably primed by a No. 8 detonator or by "CORDTEX" detonating fuse as an alternative to the use of high explosive primers. **Below 10° C,** an HE primer is recommended.

Strength: accurately controlled
"MOLANITE" has an energy yield similar to AN Gelignite 60 and is designed for the diverse conditions encountered in New Zealand.

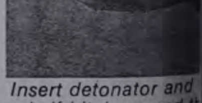
Operator comfort: no headaches
"MOLANITE" does not produce the headaches symptomatic of nitro-glycerine explosives and there are no fumes in storage.

Water resistant: for all conditions
The firm gel structure of "MOLANITE" has inherent water resistant properties which permit it to be loaded into water filled blast-holes without detracting from its explosive properties.

Electric Deton



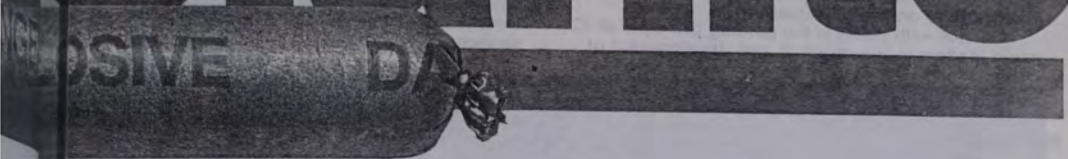
Pierce one end



Insert detonator and a half hitch around th cartridge

Cartridge ready for charging

olanite®



g

"Cordtex"

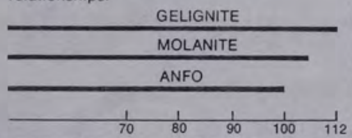
a ve hitch around
cartridge

rtrige ready for
ing into hole

technical data

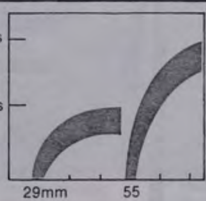
Weight strength

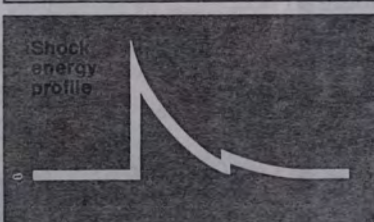
The "MOLANITE" grade number represents weight strength relative to that of ANFO (100) as measured underwater by seismic evaluation. The chart shows these relationships.



Detonation velocity

(tested unconfined)





Explosive Sizes and Cartridge Counts

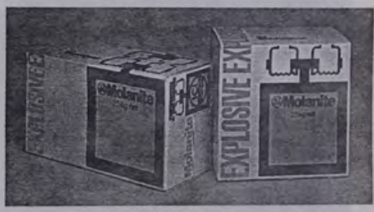
	Cartridge Diameter (mm)	Cartridge Length (mm)	Cartridge Weight	Number per Case
MOLANITE	25	300	208g	120
	29	300	238g	105
	40	500	676g	37
	55	500	1.5kg	17
	65	500	2.1kg	12
	80	500	3.1kg	8
	90	500	4.2kg	6
	100	500	5.0kg	5

Density

The packaged density of "MOLANITE" is 1.18 gram/cc.

Packaging

"MOLANITE" cartridges are packed into fibre board cases containing 25 kg of explosives. Each individual cartridge is packed in polythene layflat tubing.



"Molanite" is available in these stock sizes - ICI can make any diameter or length cartridge on request.

ICI-powermasters at your command

ICI research and development is your guarantee of a dependable, powerful product range to optimise your blasting.
In keeping with the high standard of reliability of all ICI Explosive, "MOLANITE" is subject to stringent quality control and testing. This extends from laboratory to on-the-job situation.

Service with safety is the guiding principle of ICI, world leaders in the research and development of explosives and techniques for their application.

ICI "Molanite" is manufactured in New Zealand to satisfy a broad spectrum of specifically local requirements. It is always readily available; and it is backed up by a full technical advisory service which is freely available for blasting consultation.

Included is a Quarry Design Service and Blasting Courses. ICI offer you the **complete** explosives service.

Everything for blasting ...anywhere in N.Z.

In addition to manufacture, sales and technical service, ICI supply a full range of back-up accessories:
DETONATORS • DETONATING FUSE • IGNITER CORD • EXPLODERS • VIBRATION DETECTING EQUIPMENT
All products are available in continuous supply throughout New Zealand.

1. AN Gelatine Dynamite 95
2. "Molanite" large diameter
3. "Molanite" small diameter
4. AN Gelignite 60
5. Plastergel
6. A3 Monobel
7. Ajax
8. "L" Series Millisecond Delay Detonator
9. Half Second Delay Detonator
10. "Anzomex" Booster 'M'
11. "Anzomex" Booster 'D'
12. "Anzomex" Booster 'A'
13. Electric Detonator
14. Submarine Detonator
15. Safety Fuse
16. Plain Detonator
17. Igniter Cord Connector
18. Seismic Detonator
19. Ammonium Nitrate
20. "Amex"
21. Blasting Powder
22. "Aluminex"
23. Blue Cordtex
24. Premium Cordtex
25. Igniter Cord Fast
26. "Metabel"
27. Electric lighter
28. DRC's, L. to R: 35, 45, 25, 15 m/s

POWERMASTERS AT YOUR COMMAND

ICI

ICI New Zealand Limited
Explosives Division

ICI New Zealand Limited, Box 900, Auckland, New Zealand.

ANNEX L TO
TOKELAU RECON REPORT
DATED 10 MAY 85

POWERMASTERS AT YOUR COMMAND

ICI Explosives

EXPLOSIVES in ACTION

Volume 1 Number 4 March 1980

ICI New Zealand Limited Explosives Division has marketed the packaged slurry explosive "Molanite" for some years now. However, its mechanics of detonation are not generally fully understood by blasters. This edition of "EXPLOSIVES IN ACTION" will explain its nature, and examine factors which can influence its performance.

Slurry Explosives—a review of their characteristics and initiation requirements

HISTORY

In the mid 1950's the development of fuel oil sensitised prilled ammonium nitrate (ANFO), revolutionized the explosives industry. However, this new source of cheap explosive energy had two significant limitations. ANFO is readily desensitised by relatively small quantities of water while its low density and detonation pressures restrict its effectiveness on the hardest rocks, particularly in the "toe" of the burdens of blastholes.

Although the addition of aluminium powders to ANFO gives improved energy characteristics, the water desensitisation problem still remains. This disadvantage led to further extensive research and a basic knowledge of the mechanics of detonation provides the key to understanding the resulting development of slurry explosives such as "Molanite".

MECHANICS OF DETONATION

An explosive consists of solids, gases and liquids which rely upon the introduction of a specific energy input for reaction. The detonation thus creates an intense supersonic shock wave which travels through the explosive compressing it to a high density. Then chemical reaction occurs with the conversion of the explosive ingredients behind the primary reaction zone into mainly gaseous products at high temperature. This in turn sustains the shock wave at a constant velocity throughout the explosive.

It is therefore most important that the initiators of high explosives produce the proper pressure and temperature conditions to efficiently promote the optimum reaction from a particular explosive's ingredients.

An additional means of sustaining the detonation process of an explosive is to increase the pressure of the initiating shock (i.e. priming), or by the introduction of "hot spots" into an explosive. These

MAJOR EXPANSION SCHEME ANNOUNCEMENT

In a major development programme, details of which are just released, ICI New Zealand will invest about $1 million in the building of new facilities to produce water gel or slurry explosives.

The manager of ICI New Zealand Explosives Division, Dr J.A. Kernohan, said the present factory, built twelve years ago at Kawakawa Bay in the Firth of Thames, has been operating at near full capacity to meet market demands for its "Molanite" explosive.

"The new extension will add to capacity and incorporates new concepts and the latest overseas technology in terms of plant design, formulation and packaging design.

"Increased manufacturing capacity will enable further replacement of imported products by local manufacture, together with expanded customer servicing."
Work on the new expansion is expected to be completed by the end of the year.

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s the "hot spots" are
ession of tiny air or gas

"Molanite" retains the
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ation. "*The quantity and
bubbles is critical for
lurry explosives.*" Any
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slurry explosives will
All explosives are
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, relative to volume and
ult. It is these two areas
standing as to their
of all slurry explosives.

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Molanite" can be
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or underwater blasting

sites. In these circumstances the density of "Molanite" is increased as the tiny air bubbles within the explosive are compressed. The resulting reduction in sensitivity (i.e. available "hot spots" for compression), causes lowered explosive efficiency and often erratic blast results despite a higher volume of explosives per metre of borehole. In general terms, "Molanite" in its normal packaging should not be used in underwater blasts more than 20m deep.
ICI makes special rigid packaged charges for underwater blasting tasks where "Molanite" is required. We can provide specialist advice on specific explosive problems associated with this area of blasting.

"Temperature"

Although normally sensitive to a Number 8 strength detonator for initiation, slurry explosives are less sensitive when the size of air bubbles is reduced by low temperature. When the temperature drops below 10°C, it is recommended that a booster from our "Anzomex" range be employed as a primer.

"Tamping"

Excessive tamping of "Molanite" can cause physical destruction of the air bubble and fuel relationship. This is particularly applicable in the small diameter cartridge range. Firm tamping of stemming material is suggested to provide maximum charge confinement.

DIVISIONAL PROFILE

ALAN CHRISTENSEN

Alan has recently been appointed South Island representative for Explosives Division. He is based in Alexandra to keep close contact with our customers in Otago, Southland, and Canterbury.
Alan has been involved with the distribution of explosives at our Waitawa magazine area for the last two years.
Before joining ICI he was involved with the fishing and transport industries.

Dynamic Pressure Desensitisa

"Detonating Cord"

STORAGE

"Channel Effect"

Shock waves move through different mediums such as air, water and rocks at different speeds. Therefore, if there is a significant gap between a "Molanite" charge and a borehole wall, the shock from a detonation will be moving at two speeds. The air shock always has a higher velocity than the detonation velocity and as it proceeds, the detonation front causes a progressive compression of the explosive until the "Molanite" density is so high, the explosive can fail.
(N.B. Although this phenomenon occurs with N.G. sensitised explosives, it does not have the same result).

Dynamic Pressure Desensitisation

This phenomenon should be considered when using closely spaced boreholes such as "Burn cuts" in tunnelling, pole holes and some trench blasting situations. Bedding planes, or blast induced cracks intersecting an unfired borehole from a preceding millisecond delay shothole, can provide a path for gas pressure. Gas streaming into this closely adjoining borehole can therefore pressurise the explosive and effectively desensitise it at its time of detonation.
Porous, weak sandstones, limestones, coal, plastic clays or material with a density of less than 2.3g/cm^3 could be expected to give difficulties. It should be stressed, that this phenomenon can be controlled in the following ways:

(i) Ensure that the charge approximates the borehole diameter, where practicable:
(ii) Utilize a delay period of at least 50 milliseconds between the boreholes concerned:
(iii) Use a wedge cut in tunnel rounds, or consult ICI technical staff about a revised "burn cut" design to suit the conditions.

These dynamic pressure effects appear to be transitory and the explosive can be detonated later with a Number 8 strength detonator.

"Detonating Cord"

Low order detonation has been seen in secondary blasting operations where some slurry explosive ingredients have been left on the sides of post blast borehole walls and the rock breakage has been poor. While temperature, tamping effort, degree of confinement, borehole/explosive diameters and length need careful reviewing, the influence of detonating cord should not be ignored. Transfer of the shock energy of detonating cord to small diameter/lengths of "Molanite" cartridges does not automatically ensure that the explosive attains its optimum performance. This is particularly critical when using 5-8g/m (explosive core) detonating cord as the initiator may not be in positive contact with the explosive, or, some of the above factors also apply. In such cases a Number 8 strength detonator may be a more preferable initiator.

STORAGE

Our experience has shown that age affects slurry explosives' sensitivity, and cartridge rigidity also suffers. Although we have fired (using a Number 6 strength detonator), "Molanite" cartridges four years old, we recommend a storage life of twelve months in New Zealand temperatures. Regular explosive stock rotation is most important in geographical areas where pronounced temperature variations prevail.

PRIMING

Priming "Molanite"

Under most circumstances "Molanite" is successfully initiated by detonating cord or Number 8 strength detonators. Proper priming will overcome many of the extraneous pressure and temperature effects mentioned earlier. The primer must have the following properties:

(i) A higher rate of velocity of detonation,
(ii) Produce high shock pressure,
(iii) Be as close as possible to the borehole diameter.

ICI's range of cast P.E.T.N./T.N.T. "Anzomex" boosters are ideal for this purpose.

"Molanite" primers

Conversely, "Molanite" itself can be used as a primer of dry blasting agents (D.B.A.'s) such as ANFO, "Amex" and "Aluminex". The minimum length of these primers should equal twice the borehole diameter of the common range of blastholes drilled in New Zealand for two reasons:

(i) To prevent bridging when loading into the borehole,
(ii) To ensure that adequate detonation velocity and pressure is reached within the primer.

The diameter of a "Molanite" primer should be as close as possible to the borehole diameter when using detonating cord as the initiator, to ensure intimate contact. This can be best achieved by slitting the primer prior to loading, to facilitate slumping and full cross sectional filling of the borehole. Although special short primers of "Molanite" can be made at our factory at short notice, the gel consistency of "Molanite" allows a blaster to cut primers from the standard cartridges to suit his own requirements. This method is the most commonly adopted practice in New Zealand and has an economic advantage over cast boosters for priming dry blasting agents.
The pictures below illustrate the various methods of priming "Molanite" and using this explosive as a primer in its own right.

DETONATING CORD

1. Tie a clove hitch around the cartridge.

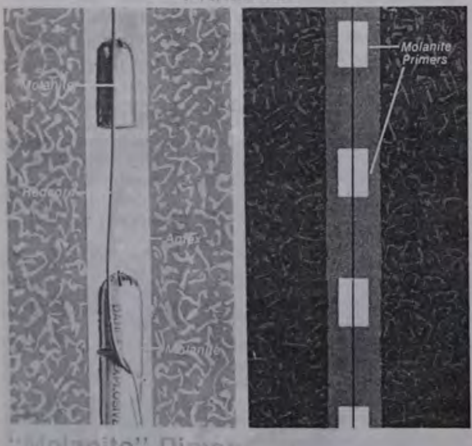
2. Cartridge ready for lowering into hole.

ELECTRIC DETONATOR

3. Insert detonator and take two half hitches round the cartridge (as shown in Fig. 2)

4. Cartridge ready for charging.

PRIMING



"Molanite" Dimen

The introduction of metrics in New Zealand and its implications for product dimensions and blast design, led to ICI adopting 200mm and 500mm lengths for small and large diameter cartridges of "Molanite" respectively. These dimensions coupled with packaging in 25 kg cases, greatly simplifies blast design calculations.

Another consideration has been the effect of ragged boreholes and worn drill bits reducing the nominal borehole size thus preventing the loading of 65mm diameter cartridges into 75mm blastholes. Recognizing this problem, ICI has introduced a 60mm diameter cartridge into its "Molanite" range of explosives. This size allows for ease of borehole loading in such conditions while retaining the necessary degree of borehole coupling for optimum density per metre of borehole. This function is most important where stubborn "toe" conditions apply, as well as allowing optimisation of the drilling pattern for total "work" and cost efficiency from the explosives.

The table below lists our current standard range of cartridged "Molanite".

Cartridged Diameter	Cartridged Length
25 mm	200 mm
29 mm	200 mm
32 mm	200 mm
40 mm	500 mm
55 mm	500 mm
60 mm	500 mm
65 mm	500 mm
80 mm	500 mm
90 mm	500 mm
100 mm	500 mm
115 mm	500 mm

General

Slurry explosives such as "Molanite" can be produced in various strengths and degrees of rigidity. Our experience has shown that a balancing of these factors (i.e. rigidity versus slump), is necessary to meet the general blasting requirements of cartridged slurry explosives in New Zealand.

With reasonable forward notice, it is possible for ICI to vary the diameter or length of a cartridge of "Molanite", and as for the Bluff Harbour deepening project, introduce specially packaged rigid unit charges to meet the unusually demanding factors applying there.

It should be appreciated however, that slurry explosives are but one of a broad range of ICI explosive products. Slurry explosives DO NOT fulfil every requirement for blasting tasks and must therefore be considered on a "suitability for the job in hand" basis. Blast designers should not hesitate to seek our technical assistance on such matters, or for general or specialized advice on all facets of blasting.

Summary

Several thousand tonnes of "Molanite" have been used in the last few years and ICI's "Molanite" now ranks as the second most commonly used explosive in New Zealand — only slightly behind ANFO. Provided blasters realise that "Molanite" has different properties and characteristics from nitroglycerine explosives and recognise the factors which influence its performance, they will enjoy the user comfort and economic advantages to be gained from this explosive.

"Explosives in Action" is published by the Explosives Division of ICI New Zealand Ltd, P.O. Box 900, Auckland, New Zealand.

APPENDIX 4 TO
ANNEX L TO
TOKELAU RECON REPORT
DATED 10 MAY 85

Flexicord

'Flexicord' is a strong, reliable detonating cord especially developed to possess properties which meet the requirements of all detonating cord users.

'Flexicord' has a core of high explosive (PETN) treated with a water-repellent agent. The core is encased in a tube of polyester tape bound by polypropylene yarns which are covered in a flexible PVC sheathing. Outer yarns are firmly attached to the plastic sheathing with an adhesive.

The combination of treated explosive core, polypropylene yarns, plastic covering and outer covering has produced a cord which has excellent water-repelling properties, high tensile strength, good flexibility, knottability and abrasion resistance. The cord has high visibility, provided by the white outer covering with red and blue stripes, and has excellent storage handling and firing characteristics in all conditions likely to be encountered in the field.

'Flexicord' has the ability to withstand suddenly applied loads and to stretch and detonate reliably under severe conditions of rock movement encountered in delay firing.

Properties

Colour	White, red/blue stripes
VOD	7140-7500 metres/sec
Tensile strength	125-130 kg
External diameter	4.5 mm approx
Coreload (PETN)	10.0 g/m (nominal)
Weight	23.5 kg/1000 m approx

Safety

'Flexicord' is insensitive to initiation by ordinary impact, friction or shock, and to static electricity and stray currents.

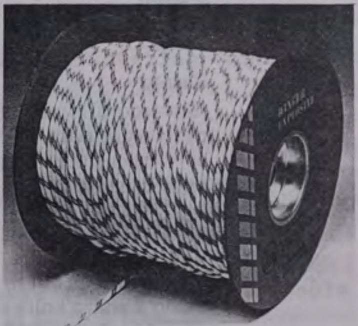
Field of application

'Flexicord' may be used in conditions of severe abrasion. Its superior handling, flexibility and knot-holding properties are beneficial where water or oil (from ANFO) is present.

Packaging

'Flexicord' is packed 1000 metres to a case (4 x 250 metre reels).

This product is not waxy to touch or grasp in warm weather. Also 'Flexicord' doesn't "spring" the knots one ties as for our plastic-sheathed Premium and Blue "Cordtex". A special additive to the PETN explosive core has been used to further improve water resistance.



ICI Shearcord

'Shearcord' is similar to Premium 'Cordtex' with a core of the high explosive PETN encased in a high strength carcase which is covered by a flexible jacket of polythene.
The difference between the two is that 'Shearcord' is much heavier in construction, and the charge weight of PETN is seven times that of Premium 'Cordtex'. The heavy charge weight makes 'Shearcord' suitable for smooth-wall blasting techniques.

Properties

Colour	Orange
VOD	6400 metres/sec
Tensile strength	120 kg
External diameter	10.5 mm
Coreload (PETN)	70 gram/metre
Weight	100 kg/1000 m

Safety

'Shearcord' is insensitive to initiation by ordinary impact, friction, or shock, and very insensitive to static electricity and stray currents.

Use

'Shearcord' is cut to length as required using a sharp knife or approved cutter. All cut ends should be secured by using special end caps to prevent loss of explosive powder core.
Initiation may be achieved by attaching longitudinally either a detonator or Premium 'Cordtex' to the 'Shearcord'.

Packing

'Shearcord' is packed on 50 metre reels, with 4 reels (i.e. 200 metres) per case. 'Shearcord' End Caps are packed in plastic bags of 50, with 4 bags (i.e. 200 end caps) per carton, and 5 cartons (i.e. 1000 end caps) per case.

POWERMASTERS AT YOUR COMMAND

ICI Explosives

ICI New Zealand Ltd
Explosives Division
Box 900 Auckland

DRILLING EQUIPMENT

1. Attached as Appendices to this Annex are copies of brochures produced by Ingersol-Rand Ltd (drilling equipment). The Appendices contain information about the recommended air-track drill and compressor required for the tasks in Tokelau.

2. Enclosure 2 contains detailed information.

3. The recommended airtrack drill is the "LM-100 Crawlair Drill". It appears to be a most suitable piece of equipment for employment in Tokelau and has the following advantages; it is:

a. light weight;

b. easily operated by one man;

c. able to be transported by local aluminium boats with relative ease;

d. capable of approximately 500% more production during the same time as hand operated tools;

e. suitable for other Army tasks associated with quarrying and blasting;

f. cost effective; and

g. fitted with an independant rotation drifter, the YD 90.

Performance

4. The LM-100 will be employed on Tokelau drilling 1.4 m deep boreholes of 50 mm diameter. The following data has been used for planning purposes:

a. Rock type - Grey Wacke (no figures available for coral)

hole depth	- 9 m	12 m	15 m
time to drill	- 18 mins	22 mins	27 mins
overall time per hole	- 30.5 mins	37 mins	44 mins

b. Overall time per hole includes:

(1) time for drilling,

(2) rod tube handling,

/(3) movement

Shearcord

... high explosive PETN encased in a high ... flexible jacket of polythene.

... PETN is seven times that of Premium 'Cordtex'. The heavy charge weight makes 'Shearcord' suitable for smooth-wall blasting techniques.

Properties

Tensile strength	120 kg
External diameter	[illegible]
Coreload (PETN)	70 grams/metre
Weight	100 kg/1000 m

Safety

'Shearcord' is insensitive to initiation by ordinary impact, friction, or shock, and very insensitive to static electricity and stray currents.

Use

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POWERMASTERS AT YOUR COMMAND

ICI Explosives

ICI New Zealand Ltd

Explosives Division

(3) movement to next hole,

(4) line-up and colaring, and

(5) total time per hole plus 5% contingency factor.

5. The LM-100 requires a minimum of 375 CFM supply of air. It also recommended that the P375 Portable Compressor be purchased for the task. The P375 is a diesel compressor and has the following advantages; it:

a. its wheel mounted;

b. has a low centre of gravity;

c. has a hand brake;

d. has a tow bar that can be adjusted for height; and

e. has four wheels.

6. Detailed costs of LM-100 and P375 compresor are included in Enclosure 2.

APPENDIX 1 TO
ANNEX M TO
TOKELAU RECON REPORT
DATED 10 MAY 85

The versatile LM-100 Crawlair drill. Small in size

It's a lightweight energy-saving drifter rig for 32-64 mm (1¼-2½") holes.

Don't let the small size of this husky little drilling rig fool you. It's a fully-mechanized, self-propelled Crawlair drill that does all the heavy work for you. It trams easily from hole to hole at the touch of a throttle, towing a portable air compressor. The drill tower is quickly positioned by effortless hydraulic cylinder operation.

With the YD-90 drifter, it handles a 3048 mm (10') rod change, with 32 mm (1.25") rods, threaded bits and couplings, to depths 12 m (40') at maximum efficiency.

Simple, safe one-man operation. All tramming and positioning controls are located at the rear of the machine for easy operation. Drilling controls, can be mounted on the tower or at the side of the machine, for convenience in either deep-hole or single-pass drilling.

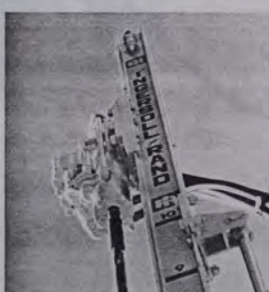
Rugged crawler construction. With two independently-controlled 7 hp tramming-air motors, it can climb a 35° grade.

Track oscillation. Heavy steel main frame has walking-beam track oscillation that permits each track to tilt up or down to match ground irregularities.

More powerful hydraulics. A 3-hp hydraulic pump motor assures faster positioning.

Air and oil gages. Continuous indication of air pressure and lubricator oil level take the guesswork out of drill operation.

Works well in close quarters.



Independent-rotation drifter.

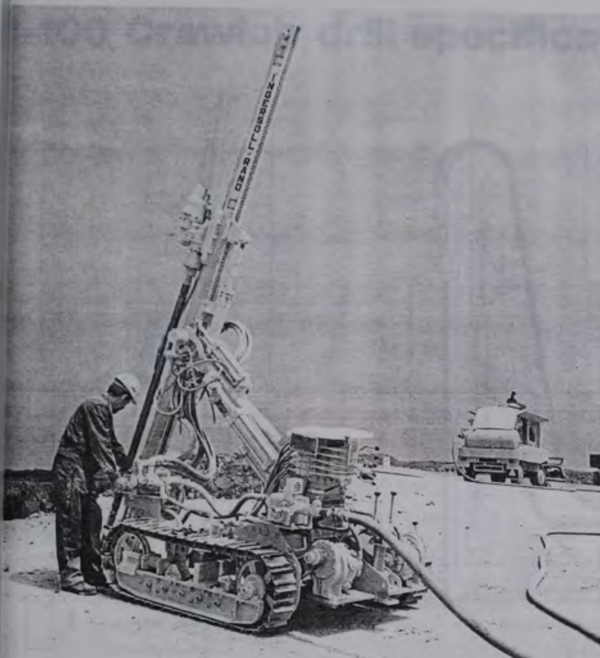
Lifts easily for shaft sinking.

Independent rotation drifter. The YD-90 air drifter has ample power for drilling holes to 64 mm (2½") in diameter. Integral air motor drive provides independent rotation with infinitely variable speed control.

Uses little air. With a P425 Spiro-Flo® compressor, there's plenty of air to operate the drill, rig and optional dry dust collector.

Rough terrain is no problem.

gin performance.



Exhaust and impact noise go right down the hole with the bit.

The AT-480 dust collector, available with YD-90 drifter or DHD-09 Down-hole drill, uses only 2 m^3/min (70 cfm) of 7 kg/cm^2 (100 psi) air.

It's a low-noise deep-drilling downhole rig for 85-90 mm (3⅜-3½") holes.

Equipped with a rotary head and larger centralizer, the LM-100 gives you all the Crawlair benefits, plus the basic advantages of Downhole drilling—with the Ingersoll-Rand DHD-09 Downhole drill.

Drills faster on deep holes because penetration rate doesn't fall off with each rod added to the string.

Uses less air because the same air does double duty, powering the drill and then cleaning the hole.

Drills straighter because the Downhole drill is less easily deflected off-course by varying strata.

Extends rod life because no impact forces are transmitted through the drill rod.

The DHD-09 Downhole drill is engineered and built to provide top performance at rock-bottom cost. Penetration is proportional to the air pressure across the drill. Check these other I-R features:

Stop-action plunger automatically stops the hammer action whenever the drill is raised.

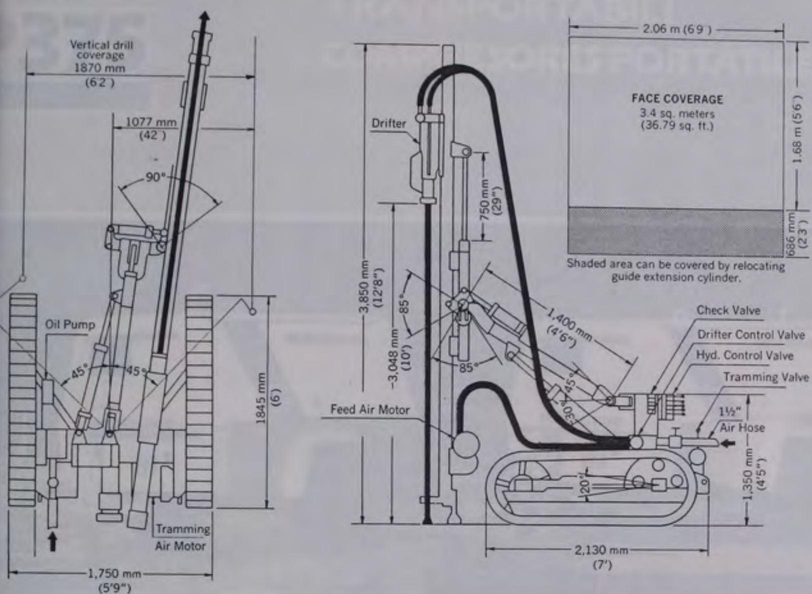
Wear sleeve surrounding the drill cylinder can be reversed to extend sleeve life. It's easy and economical to replace.

Piston delivers full impact force directly on the bit at any depth of hole.

Bit retaining key prevents accidental dropout yet permits easy removal for grinding or replacement.

INGERSOLL-RAND
DRILLING EQUIPMENT

.l-100 Crawlair drill specifications



...nensions		
...erall length (...tower horiz.)	3850 mm	12'8"
...ght (tower ...oriz.)	1350 mm	4'5"
...erall width	1750 mm	5'9"
...ound clearance	230 mm	9"
...ck width	204 mm	8"
...ck length	1845 mm	6'⅝"
...ck oscillation	20°	20°
...sitioning		
...om lift	45° up, 30° down	
...om swing	45° right, 45° left	
...ide swing (...horizontal)	45° right, 45° left	
...ide dump	85° (two positions)	
...amming		
... motors	Two 7-hp (one per track)	
...amming speed	0 to 2.6 kph	0 to 1.6 mph
...mbing ability	35° grade	35° grade
...awbar pull	1400 kg	3100 lb

Drilling Range		
Hole diameter (YD-90)	44-64 mm	1¾-2½"
Hole diameter (DHD-09)	85-90 mm	3⅜-3½"
Rod diameter	32 mm round	1¼" round
Rod length	3048 mm	10'0"
Drilling range width	2050 mm	6'9"
Horizontal height, maximum	2350 mm	7'8½"
Horizontal height, minimum	680 mm	2'2¾"
Hydraulic Pump Air Motor		3 hp
Total Weight*	2450 kg	5400 lb
Recommended Air Compressor		
	12 m³/min at kg/cm²	425 cfm at 100 psi

*With YD-90 drifter.

Model YD-90 Drifter		
Bore and stroke	90 × 85 mm	3½ × 3⅜"
Blows per minute	1600	
Rotation	0 to 150 rpm	
Weight	85 kg	187 lb
Model DHD-09 Downhole Drill		
Weight (less bit)	24 kg	53 lb
Length (bit extended)	965 mm	35.6"
Outside diameter	76 mm	3"
Bit diameters	85 mm 90 mm	3⅜" 3½"
Air usage	3.5 m³/min at 7 kg/cm²	125 cfm at 100 psi
ZD45 Rotary Head		
Max. torque	79.5 kg-m	575 ft-lb
RPM range	0-65	
Horsepower	4.0 max	
Air usage at 25 rpm	3.4 m³/min	120 cfm
Weight	91 kg	200 lb

...gsoll-Rand Company
... Drill Division
...psburg, New Jersey 08865

INGERSOLL-RAND®
DRILLING EQUIPMENT

...66-A ©1977, 1981 Ingersoll-Rand Co. Printed in U.S.A.

APPENDIX 2 TO
ANNEX M TO
TOKELAU RECON REPORT
DATED 10 MAY 85

P140
P175
P250
P375

PORTABLE COMPRESSORS
COMPRESSEURS MOBILES
FAHRBAREN KOMPRESSOREN
MOTORCOMPRESSORI TRANSPORTABILI
COMPRESORES PORTÁTILES

INGERSOLL-RAND
CONSTRUCTION EQUIPMENT

P 40/P175/P250/P375 WHISPERISED®

A of precision engineered portable compressors, designed for low maintenance, maximum efficiency, economic operation and mum operational life.

Operation
dels meet or surpass CAGI-PNEUROP noise emission rds, and can therefore be used in areas where strict noise on standards are in force.

Duty Engines
dels incorporate industrial type diesel engines which, dent on unit selected, are air or water cooled and deliver from (38 kw) to 112 bhp (83.5 kw) at a speed of 2.500 r.p.m. All provide outstanding fuel economy.

ds
essor rotors are precision-machined to the ideal design Other components are precision die-cast. The result: greater cy and lower fuel consumption.
es and air-end assemblies are mounted on heavy gauge all-steel chassis by means of special rubber mounts, thereby isolating vibration.

Air Regulation
The Stepless system, from idle to full engine speed, allows for a continuous, smooth flow of compressed air output in response to air demand.

Air Oil Separation
Less than 10 p.p.m. due to a two-stage separation system.

Unique Cooling
All models are designed to operate with doors closed. The unique cooling system allows the units to operate in ambient conditions, depending on the machine model, of up to 125° (52°C).

Two Stage Dry Type Air Filters
The engine and air-end are protected by separate air intake filters equipped with filter element restriction indicators.

Running Gear
Two types of torsion bar suspended running gear are available. The first incorporates a tow-bar that can be adjusted to suit the height of the towing vehicle and meets European specifications. The other is a rigid towing bar running gear which meets EEC specifications. Wide wheel base, high ground clearance and a low centre of gravity make all models very stable on even the roughest ground. The over run brake system provides for excellent braking characteristics. A hand parking brake which allows for safe parking is a standard fitting.

Ease of Access
The large lockable doors, the lifting of which is aided by gas struts, open wide allowing full accessibility to all maintenance areas and the large tool storage space.

Controls and Instrumentation
The maintenance-free control system provides for automatic shutdown by high discharge air temperatures, low engine oil pressure, or high engine temperature. Signal lights show the cause of protective shutdown. Instruments include discharge air pressure gauge and engine hour meter. Starting and operating controls are located in a lockable enclosure for protection against vandalism.

Un amme de compresseurs mobiles fabriquée avec précision et r pour un entretien réduit, un rendement maximum, un nnement économique et une durée de vie opérationnelle um.

ronnement silencieux
s modèles satisfont ou dépassent les normes d'émission de AGI-PNEUROP, et peuvent donc être utilisés dans les s où des normes strictes d'émission de bruit sont en vigueur.

rs grande puissance
es modèles sont équipés de moteurs diesel industriels qui, la machine choisie, sont refroidis par air ou par eau une puissance de 38 kW (51 ch) à 83,5 kW (112 ch) t/mn. Tous les modèles offrent une excellente économie de ant.

resseurs
ors du compresseur sont usinés avec précision selon le profil Les autres composants sont s par moulage mécanique de précision. Le résultat: un ment plus élevé et une consommation de carburant plus
oteurs et les compresseurs sont montés sur des châssis en tôle d'acier de forte épaisseur par l'intermédiaire de plots spéciaux en caoutchouc, isolant ainsi des vibrations.

Régulation d'air
Le système progressif, du ralenti à la pleine vitesse, pemet un débit d'air comprimé uniforme répondant totalement à la demande d'air.

Séparation air-huile
Inférieure à 10 p.p.m. grâce au système de séparation à deux étages.

Refroidissement unique
Tous les modèles sont conçus pour pouvoir fonctionner avec les portes fermées. Le système de refroidissement unique permet aux unités de fonctionner dans des conditions ambiantes allant jusqu'a 52°C, en fonction du modèle de machine.

Filtres à air secs bi-étages
Le moteur et l'ensemble compresseur sont protégés par des filtres d'admission séparés, équipés d'indicateurs de colmatage de l'élément filtrant.

Châssis
Deux types de châssis à suspension par barres de torsion sont disponibles. Le premier comporte un timon réglable en fonction de la hauteur du véhicule de remorquage et est conforme aux spécifications européennes. Le second est un châssis à timon rigide conforme aux spécifications de la C.E.E. Des roues largement espacées, une garde au sol importante et un centre de gravité bas rendent tous les modèles très stables, même sur les terrains les plus accidentés. Le système de frein d'emballement offre d'excellentes caractéristiques de freinage. Un frein de stationnement est fourni en équipement standard.

Facilité d'accès
Les grandes portes verrouillables, dont l'ouverture est assisté par des équilibreurs à gaz, s'ouvrent sur une grande largeur et donnent une accessibilité totale à tous les organes à entretenir et au grand espace de rangement des outils.

Commandes et instrumentation
Le système de commande sans entretien assure un arrêt automatique en cas de température élevée d'air de service, de faible pression d'huile ou de haute température du moteur. Des lampes indicatrices donnent la cause de l'arrêt. Les instruments comprennent un manomètre d'air de service et un compteur horaire du moteur. Les commandes de mise en marche et d'exploitation sont regroupées dans un boîtier anti-vaudalisme.

---

he fahrbarer Schraubenkompressoren mit geringem ngsaufwand, langer Lebensdauer und wirtschaftlichem b.

schpegel
Modelle unterschreiten die AVV-Normen. Sie können setzt werden, wo Geräusche auf ein Mindestmaß gesetzt werden müssen.

leistungsmotoren
odelle besitzen Dieselmotoren, die je nach Modell entweder oder wassergekühlt sind. Die Leistung dieser Motoren liegt nen 38 und 83,5 kW bei 2500 U/min. Sie zeichnen sich alle hohe Wirtschaftlichkeit aus.

ressor
chraubenpaar wird mit engsten Toleranzen gefertigt, um das Läuferprofil zu erreichen. Andere Komponenten sind onsgegossen. Das Resultat: größere Effizienz und noch amerer Kraftstoffverbrauch. Motor– und Kompressor werden eziellen Gummidämpfern in einem Chassis aus hochwertigem montiert, um eine größere Laufruhe zu erzielen.

Liefermengenregelung
Die stufenlose Liefermengenregelung von Leerlauf bis Vollast sorgt für eine gleichmäßigen, kontinuierliche Liefermenge je nach Luftbedarf.

Luft-Öl-Abscheidung
Aufgrund eines äußerst wirksamen Zweistufen –Abscheid systems beträgt der Rest-Ölgehalt der Druckluft weniger als 10 p.p.m.

Kühlung
Alle Modelle werden mit geschlossenen Türen und Klappen betrieben. Das werksame Kühlsystem ermöglicht es, die Kompressoren, selbst bei Umgebungstemperaturen bis zu 52°C, einsuzetzen.

Zwei-Stufen-Trockeneinlaßluftfilter
Motor und Kompressor werden durch separate Lufteinlaßfilter geschützt, Filterkontrolle durch verschmutzungsanzeiger.

Fahrgestell: Straßenlage
Es sind zwei Varianten mit Drehstabfederung lieferbar. Ein Fahrgestell hat eine höhenverstellbare Zugvorrichtung, die den Spezifikationen europäischer Länder entspricht. Die andere Variante besitzt eine in der Höhe nichtverstellbare Zugvorrichtung, die EG-Bestimmungen gerecht wird. Die breite Spurweite, der hohe Bodenabstand und der niedrige Schwerpunkt sorgen für eine sehr sichere Straßenlage des Kompressors beim Schleppen sowohl auf der Straße als auch im Gelände. Die Auflauf– und Feststellbremse wirken sehr zuverlässig.

Leichte Zugänglichkeit
Die großen verschließbaren Klappen, die sich leicht durch Gasdruckfedern anheben lassen, machen alle Wartungsbereiche leicht zugänglich. Außerdem ist eine großzügige Werkzeugablage vorhanden.

Regler und Instrumente
Das Sicherheitssystem sorgt für eine automatische Stillegung des Kompressors bei zu hohen Lufttemperaturen, zu niedrigem Öldruck, zu hohen Motortemperaturen. Signalleuchten weisen auf die Ursache einer vorbeugenden Ausschaltung hin. Zu den Instrumenten gehören ein Betriebsdruck-Manometer und ein Betriebsstundenzähler. Start– und Betriebsregler können durch eine verschließbare Klappe vor unbefugtem Zugriff gesichert werden.

---

ma di motocompressori trasportabili, progettati per ridurre al la manutenzione, con la massima efficienza ed economia di io.

rosita'
modelli sono disponibili sia in versione standard che silenziata. sto secondo caso sono conformi alle norme europee vigenti e nto possono venire impiegati in zone con rigorosi regolamenti umore.

ri Diesel
motocompressori sono equipaggiati con motori diesel che, a do del modello, sono raffreddati ad aria o ad acqua ed no una potenza variabile da 51 HP (38 kW) a 83.5 HP (83.5

olare attenzione è stata posta nella riduzione dei consumi.

ressore a Vite
ri sono stati lavorati con finitura di altissima precisione cosi tutti gli altri componenti. Come risultato si sono ottenute una e efficienza e ridotti consumi di carburante.
e e compressore sono montati su di un robusto telaio in acciaio per mezzo di adeguati supporti in gomma che isolano dalle vibrazioni.

Regolazione della portata
La regolazione di tipo continuo e progressivo, dal regime di minimo al massimo numero di giri del motore, consente di soddisfare la richiesta d'aria con una erogazione uniforme.

Separazione aria olio
Meno di 10 ppm grazie di olio al sistema di separazione a due stadi.

Raffreddamento
Tutti i modelli sono stati progettati per operare a portelloni chiusi. Il sistema di raffreddamento consente di operare, a seconda del modelle, fino a una temperatura ambiente di 52°.

Filtri aria a due stadi di tipo a secco
Motore e compressore sono dotati di filtri di aspirazione completi di indicatori di intasamento dell'elemento filtrante.

Timone
Sono disponibili due differenti timone di traino.
Un tipo incorpora una barra regolabile in funzione dell'altezza del veicolo trainante e risponde alle vigenti norme europee. Un secondo modello è equipaggiato di barra fissa. L'ampia carreggiata, l'altezza da terra ed il basso baricentro garantiscono la massima stabilità anche sui tereni piu accidentati. L'impianto frenante di tipo a repulsione é sinonimo di eccellenti caratteristische di frenatura un freno meccanico di stazionamento manuale equipaggia di serie tutti i modelli.

Accessibilita'
Due grandi sportelloni con seratura a chiave il ciu sollevamento è facilitato da pistoncini a gas, permettono il massimo accesso a tutti i componenti che possono richiedere un intervento manutentivo e ad un capiente vano per lo stivaggio di attrezzi.

Pannello strumenti e comandi
Un circuito che non richiede manutenzione, comanda l'arresto del motocompressore in seguito ad alta temperatura aria allo scarico, bassa pressione olio del motore o alta temperatura motore.
Apposite spie segnalano la causa dell'arresto.
Gli strumenti comprendono unmanometro aria di scarico ed un contaore motore. I pulsanti per l'avviamento sono posizionati in un vano dotato di sportello a chiave contro atti vandalici.

---

gama de compresores portátiles de precisión, concebidos para rcionar una duración operativa máxima con economía, máx- ficiencia y reducidas necesidades de mantenimiento.

ionamiento silencioso
los modelos cumplen o exceden las normas de emisión de CAGI-PNEUROP y pueden, por lo tanto, utilizarse en zonas se aplican normas estrictas de emisión de ruido.

res para trabajos pesados
los modelos incorporan los motores diesel tipo industrial; de do con la unidad seleccionada, pueden ir enfriados por agua o entregan de 38kW a 83,5kW a una velocidad de 2.500 r.p.m. los modelos son excepcionalmente económicos en el con- de combustible.

presores
otores de los compresores se hacen mecanozados con preci- de acuerdo con el perfil de diseño ideal. Otros componentes se troquelados a precisión. El resultado es una mayor eficiencia bajo consumo de combustible.
conjuntos de motor y compresor van montados sobre un de acero grueso por medio de monturas de goma especial, ndose así de la vibración.

Regulación neumática
El sistema progresivo, desde la marcha lenta a la velocidad máxima del motor, permite una producción continua de flujo constante de aire comprimido en respuesta a las necesidades de aire.

Separación de aire y aceite
Menos de 10ppm debido al sistema de separación bietápico.

Enfriamiento excepcional
Todos los modelos se han diseñado para que functionen con las puertas cerradas. El excepcional sistema de enfriamiento permite funcionar a las unidades en condiciones ambientales que, de acuerdo con el modelo de máquina, pueden alcanzar 52°C.

Filtros neumáticos bietápicos de tipo seco
El motor y el compresor están protegidos por filtros individuales de admisión de aire, equipados con indicadores de restricción del elemento de filtro.

Sistema de rodadura
Se dispone de dos tipos de sistemas de rodadura con suspensión por ballestas. El primero incorpora una barra de remolque que se pueda ajustar para adaptarla a la altura del vehículo remolcador y cumple las especificaciones europeas. El otro es un sistema de rodadura con barra de remolque rígida que cumple las especificaciones de la CEE. La amplia base entre ruedas, elevada separación del suelo y bajo centro de gravedad, hacen que todos los modelos sean muy estables incluso en los terrenos más escabrosos. El sistema de freno de sobrevelocidad proporciona unas características excelentes de frenaja. El freno manual de aparcamiento que permite un aparcamiento seguro es un dispositivo normal.

Facilidad de acceso
Las grandes puertas con cerraduras, cuyo levantamiento se facilita por medio de cilindros de gas, se abren ampliamente permitiendo una accesibilidad completa a todas las zonas de mantenimiento y el amplio espacio de almacenamiento de herramientas.

Controles e instrumentos
El sistema de control exento de mantenimiento proporciona una interrupción automática del funcionamiento debido a elevadas temperaturas del aire de descarga, baja presión del aceite del motor o elevada temperatura del motor. Las luces indicadoras señalan la causa de la interrupción protectora del functionamiento. Los instrumentos incluyen un manómetro de aire de descarga y un contador de horas de funcionamiento del motor. Los controles de puesta en marcha y funcionamiento se hallan dentro de un compartimiento con candado para protegerlos contra el vandalismo.

ersoll-Rand 1985.
No. LN6104
d in UK

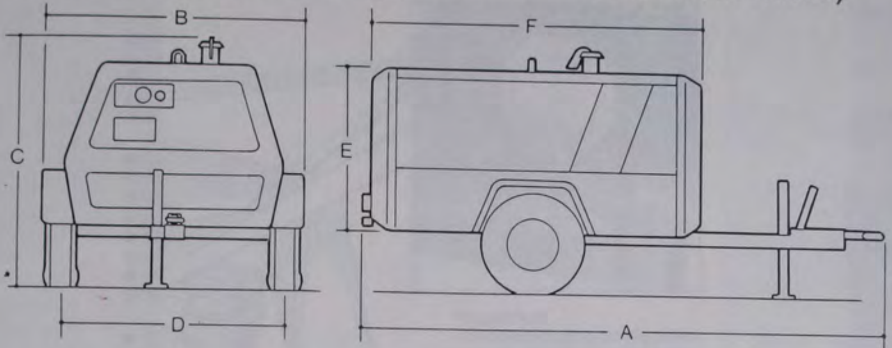
APPENDIX 3 TO
ANNEX M TO
TOKELAU RECON REPORT
DATED 10 MAY 85

Standard Portable Compressors

from 85cfm to 375cfm (2.4-10.5m^3/min)

Standard Spiro-Flo® Portable Compressors. P85-SD to P375-SD

85cfm to 375cfm at 102 psig (2.4m³min to 10.5m³min at 7.0 bar)



General Data

Model	P85SD	P100ASD	P140SP	P175SD	P250SD	*P375SD
Measurements & Weights						
A – Overall Length mm	2460	2460	3150	3150	3560	4200
B – Overall Width mm	1285	1285	1530	1530	1910	1580
C – Overall Height mm	1250	1250	1610	1610	1630	1680
D – Track Width mm	1120	1120	1321	1321	1625	1420
E – Canopy Height mm	895	895	1066	1066	1066	1070
F – Canopy Length mm	1578	1578	1930	1930	2340	2875
Net Weight (incl. lube oil) Kg	625	625	1130	1050	1300	1787
Gross Weight (incl. fuel) Kg	660	660	1180	1120	1400	1920
Tyre Size	5.60 x 13 4PR	5.60 x 13 4PR	6.70 x 13 6PR	6.70 x 15 6PR	6.70 x 15 6PR	6.70 x 13 6PR
Compressor & Performance						
Compressor Type	← SINGLE STAGE SCREW →					
Free air delivery cfm/m³ min	85/2.4	100/2.8	140/3.9	175/4.9	250/7.1	375/10.5
Normal Operating Pressure psig/bar	102/7.0	102/7.0	102/7.0	102/7.0	102/7.0	102/7.0
Max Pressure psig/bar	120/8.3	120/8.3	120/8.3	120/8.3	120/8.3	120/8.3
Air Outlets	2 x R¾"	2 x R¾"	3 x R¾"	3 x R¾"	3 x R¾" 1 x R1¼"	3 x R¾" 1 x R1¼"
Operating ambient temperature range at sea level	– 23° to 52°C	– 23° to 52°C	– 23° to 52°C	– 23° to 52°C	– 23° to 52°C	– 23° to 52°C
Engine Data						
Type	**Deutz**	**Deutz**	**Perkins**	**Deutz**	**Deutz**	**Deutz**
Model	**F2L511D**	**F2L511D**	**3.1522**	**F3L912**	**F4L912**	**F6L912**
No. of Cylinders	2	2	3	3	4	6
Bore x Stroke mm	100 x 105	100 x 105	91.4 x 127	100 x 120	100 x 120	100 x 120
Rated Speed rpm	2200	2500	2500	2500	2500	2500
No Load Speed rpm	1600	1600	1400	1400	1400	1400
kW/bhp at Rated Speed	20·9/28	23/31	33·2/44·5	40·3/54	55·2/74	83/112
Fuel Tank Capacity (ltr)	36	36	64	80	118	163

*P375SD with 4-wheel running gear

INGERSOLL-RAND

✓ Dependable ✓ Efcie

Ingersoll-Rand's range of small portable compressors covers all major applications for general construction. All units have the latest technology in screw compressor, regulation and diesel engine design.

The advantages are:

- Increased Productivity – for more Workpower
- Compact Design – so lighter in weight
- Fuel Efficient – so more air per gallon/Ltr fuel
- High Ambient Capability – up to 52°C (125°F)

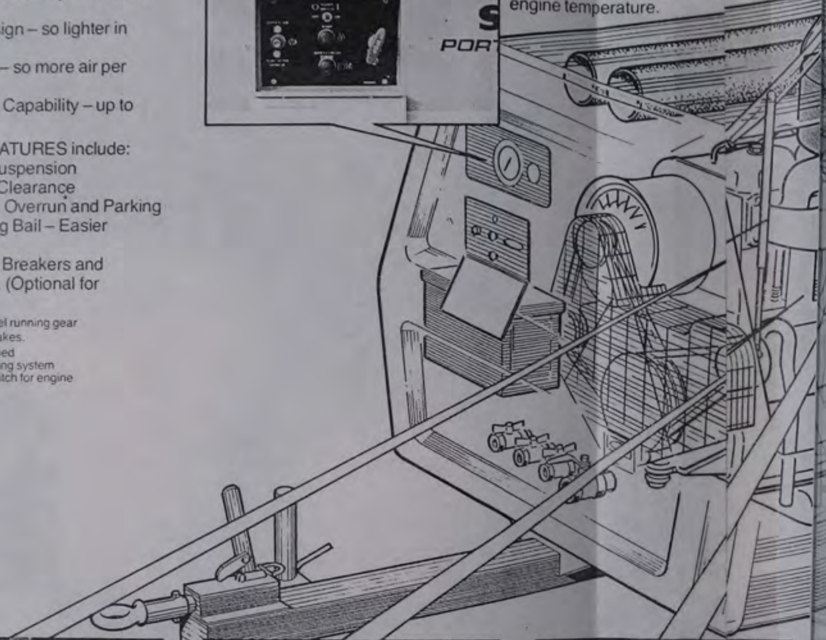
OTHER FEATURES include:

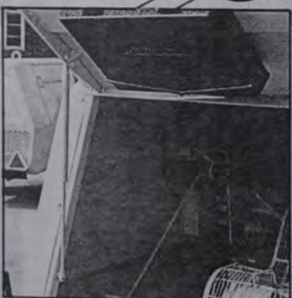
- Torsion Bar Suspension
- High Ground Clearance*
- Brakes – both Overrun and Parking
- External Lifting Bail – Easier Handling
- Toolbox – For Breakers and Accessories etc. (Optional for P85/P100)

*P-375 SD with 4-wheel running gear and has no overrun brakes.
**P85/P100 not equipped with solid-state monitoring system or high-temperature switch for engine

Instrument and contro el for ease of operation and s

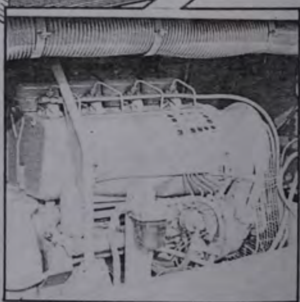
**Instruments include disc gauge, hourmeter and a solic monitoring system which pro automatic shutdown in the ev high discharge air temperatu low engine oil pressure and h engine temperature.





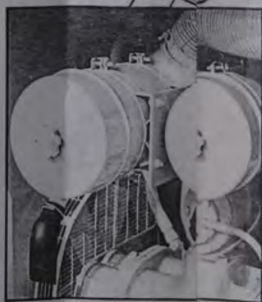
Gas spring door lifts

Both side doors open wide with minimum effort for easy access by means of gas-filled door lifts.



Reliable and fuel efficient diesel engines

All units are powered by reliable Deutz and Perkins engines.



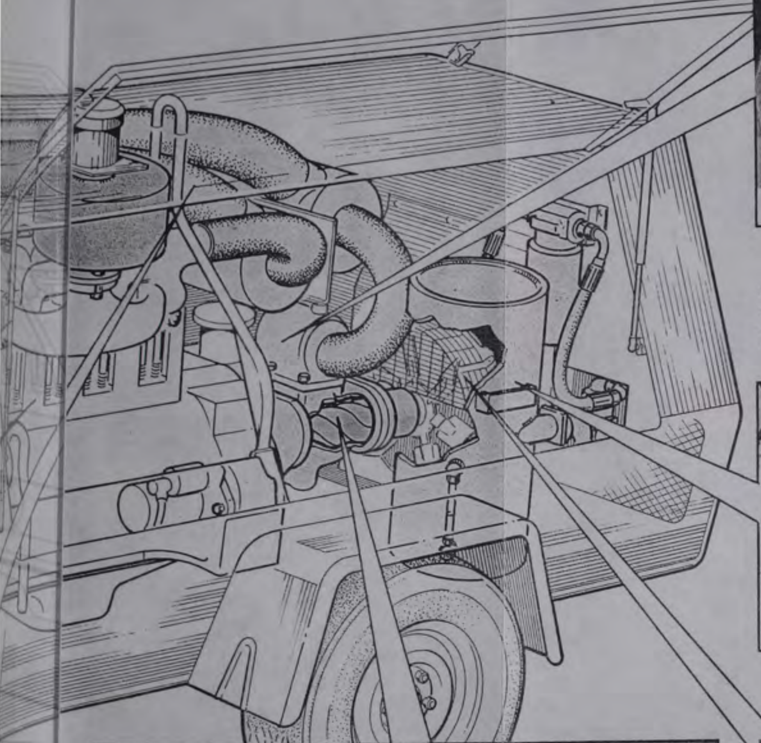
Two stage air filtrati

Engine and air end, " type" replaceable filter elementith restriction indicators are fil as standard.

INGERSOLL-RAND

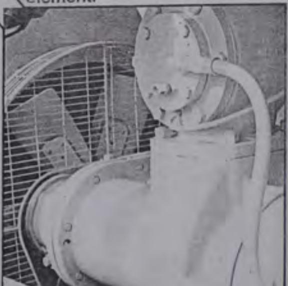
cient

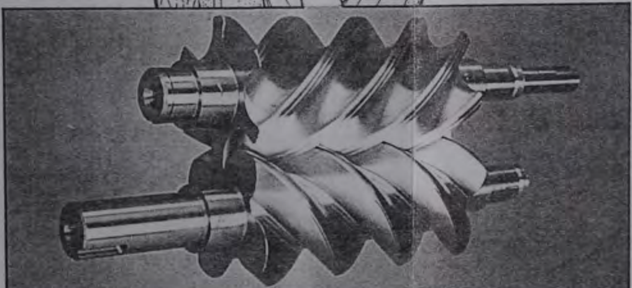
Compact



Regulation
The rolling diaphragm regulation system automatically matches engine speed to air demand to ensure smooth operation, giving longer engine life and less fuel consumption.

Efficient two stage oil separation. Compressor oil filter with replaceable spin-on type filter element.





Asymetrical profile, precision matched rotors
The rotors are machine finished to assure closer tolerances.

- Optimum Seal Strip Efficiency ● Minimum Slip Losses
- High Fuel Efficiency ● Reduced Operating Costs

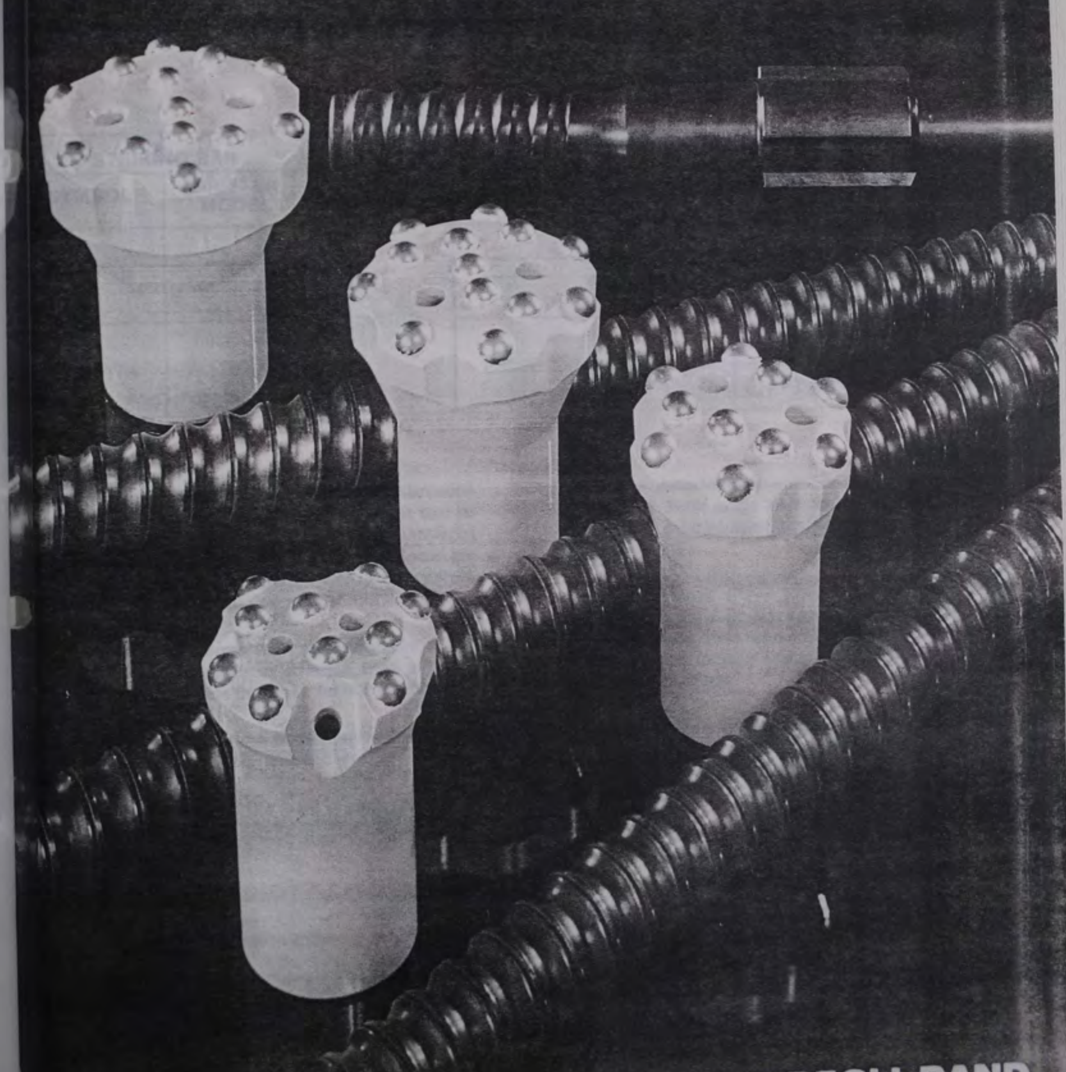
Cooling fan
Direct driven by air end.

- Less Power Required
- Lower Operating Costs
- High Ambient Operating Capability

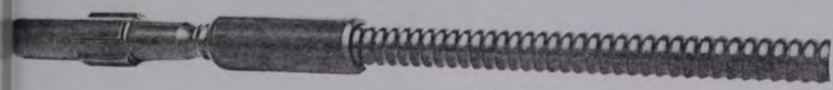
ANNEX M TO
TOKELAU RECON REPORT
DATED 10 MAY 85

IR38 SPI-RAL® steel and button bits

Patented full-length lubricating groove



INGERSOLL-RAND
DRILLING EQUIPMENT



Ingersoll-Rand IR38 Spi-Ral® Steel System: Up to 4″ (102-mm) holes

STRIKING BAR SYMBOL	STRIKING BAR DRIFTER MODEL	COUPLING SYMBOL	38 mm DRILL STEEL SYMBOL	LENGTH FT.	LENGTH M	BUTTON BITS SYMBOL	BIT SIZE IN.	BIT SIZE MM
SB38S3B	VL-120/140	C38SBB	E38SB10	10	3.1	2½B38S	2½	63
						3 B38S	3	76
SB38F17A	F-170		E38SB12	12	3.7	3½B38S	3½	89
						4 B38S	4	102

- **Full length reconditionability**— The steel is threaded over its full length. When an end wears, it can be simply cut off and the remaining length chamfered and put back into service. This can extend steel life as much as six times compared with ordinary steel, reducing inventory and overall drilling costs.
- **Rolled thread** reforms the grain structure of the steel, giving greater shear strength than with cut threads. Rolling also improves tensile strength.
- **Case hardening** provides extra toughness for wear resistance, minimizes fatigue and retards corrosion.
- **Lubrication groove** in the crest of each thread (an I-R patent) retains lubricant and assures easy detachability.
- **Easier detachability**— IR38 thread form has a steeper helix angle that requires less torque to break thread connections, saving time and extending steel life.
- **Longer thread life**— The thread also has more flank area and greater contact area between mating threads. This reduces thread deformation and wear, contributing to longer thread life between reconditionings.
- **Carset® button bits**— Advanced metallurgy provides the best combination of carbide wear and bit erosion, to maintain proper button exposure. Precision manufacture prevents stress concentrations.

INGERSOLL-RAND
DRILLING EQUIPMENT

Ingersoll-Rand Company
Rock Drill Division
Phillipsburg, NJ 08865

ANNEX N TO
TOKELAU RECON REPORT
DATED 10 MAY 85

TRANSPORTATION OF DRILLING EQUIPMENT CALCULATIONS

1. Annex M shows details of the airtrack drill and compressor that are recommended for use in Tokelau for proposed channel improvements.

2. The criteria is:

   a. width of machinery, (airtrack = 1.75 m, compressor = 1.33 m);

   b. length of machinery, (airtrack = 2.13 m, compressor = 2.88 m); and

   c. weight of machinery, (airtrack = 2000 kg approximately, compressor = 1920 kg).

3. The 'MV AVONDALE' has four forward derricks, each with a lift capacity of 5 tons. The ship can therefore load and off load airtrack and compressor.

4. Annex F details the design of the boats employed by the locals for transporting stores from the cargo ship to the Island. The internal capacity of these work boats for cargo storage is:

   a. bow to stern - 6.1 m; and

   b. side to side - 2.14 m.

Therefore, there is sufficient floor space in the boats for the airtrack drill and the compressor on separate trips. The boat's internal floor is plywood and will require additional reinforcing. It is suggested that a quantity, say 25 x 3 m lengths, 250 mm x 75 mm timber is taken to Tokelau. This can be used as dunnage for protection on the bottom of the boat.

5. The local outboard motors employed on the boats will not be sufficiently powerful to transport these loads and will require the use of the 40 hp outboard motors recommended in the Stores List at Annex O.

6. A requirement made of the manufacturers when the boats were purchased for Tokelau, was that they must be capable of carrying a 2 tonne load. This requirement was apparently achieved. It must be realised however, that the two items of equipment weigh about 2 tonnes each. It is suggested that six 44 gallon drums be available for securing to the sides of the boat, should it prove to be unsafe when loaded. The transportation of the drill will require the main boom and drifter to be removed to reduce its weight.

7. Consideration was given to constructing a raft using Tokelau boats, but was disregarded due to:

   a. the possible problems associated with supporting relatively heavy loads above the height of the sides of the boats; and

   b. the difficulty that would be encountered in safely entering the channel (two boat widths).

8. The off loading of the drill and compressor at each of the wharfs will have to be co-ordinated with mid-tide levels to allow the side of the boat to be level with the top of the wharf. An expedient ramp will be required from the wharf to the bottom of the boat to allow off loading and loading. It is suggested that the expedient ramp be constructed from the quantity of timber suggested in paragraph 4. If necessary, the ramp can be supported at mid-point by timber and if a lack of traction occurs, cleats can be cut into the timber.

9. The airtrack drill will be required to be off loaded so that it can tow the compressor off the boat.

ANNEX O TO
TOKELAU RECON REPORT
DATED 6 MAY 85

SUGGESTED STORES REQUIRED

	Qty
Ear Protection	
Gloves Industrial Leather	10 prs
Explosives	
Explosive signs	2
Gloves rubber	10 prs
Red Flags	2
Barbed Wire	qty
Short pickets	10
Fire Extinguishers (explosive and kitchen)	3
Exploder	1
D10 c/w reef	qty
Shot firing cable (100 m coil)	6 coils
Test Set	1
Crimpers	2 prs
Demolitions Pamphlet	1
Ruler 1 m	1
Personal Support	
14' x 14' tent	3
Tent 2 Man	1
Mosquito net	9
Blanket Light weight	9
Beds collapsible 'safari'	9
Chair folding	4
Stool folding	2
Table Folding large (eating off and kitchen)	1
Table folding small	1
Form GS	1
Basins Wash	2
Jerry can water 22 litre	2
Plates and eating utensils	4 sets
Tarpaulins 6 x 5 mm	1
Cooks gear including cooker, pots, utensils etc	qty
Refrigerator commercial pattern 2 m^3 capacity	1
44 Gallon drums (for buoyancy and rain water collection)	6

Generator 6.5 KVA	1
Dart Board	1
Cards	1
Projector	1
Films	Qty
Screen	1

Expendables

Fly spray	qty
Sandbags	qty
Bags multiwall	qty
Soap powder	qty
Bags plastic	qty
Swarfega	qty
Toilet paper	qty
Tape Insulation	qty
Tape Masking	qty
Twine	qty
Cordage	qty
Dazzle paint	qty

First Aid

Solar screen	qty
Sunburn lotion	qty
Foot powder	qty
Antiseptic Cream	qty
Coral cut cream	qty
Insect Repellant	qty
Elastoplast	qty
Chapstick	qty
Painkillers	qty

Drilling Equipment

Rockdrill (airtrack) (see Appendix 1 to Annex M)	1
Drill steels (see Appendix 3 to Annex M)	6
Drill bits (see Appendix 3 to Annex M)	6
Compressor 375 CFM (see Appendix 2 to Annex M)	1
Hand drifter c/w steels, bits and hoses with under water connections	2

Survey Equipment

Tape 30 m	1
Tape 100 m	1
Level c/w tripod	1
Staff	1
Compass Prismatic	1

GS Tools

Shovel GS	2
Shovel LHRM	3
Sledge Hammer 10 lb	2
Wire cutters	1 pr
Grease Guns	2
Jumping bars	3
Crow bars	2
Chainsaw	1

Diving Equipment

Diving set incl:	Mask	3 sets
	Fins	
	Snorkel	
	Knife	
	Hard soled booties	
	Cylinders c/w back pack	
	Spares	
	Protective Heavy weight wet suit	
	Regulator and mouth piece	
	Weight belt	
	Bouyancy compensators	
Compressor		1
Zodiac boat		1
Paddles		2
Outboard motor 40 hp		2
Fuel tank		1

POL

Petrol - marine
- compressors

Diesel - compressors
- generator

/2 Stroke

2 Stroke Oil - outboard motor

Engine oil - all non-2 stroke motors

Protective - grease	qty
- CRC	qty

Rationing

Own resources from New Zealand

Supplementation of fresh rations from Apia

Repayment to locals for purchase of local food

Timber, 250 mm x 75 mm x 3 m	25 lengths

ANNEX P TO
TOKELAU RECON REPORT
DATED 10 MAY 85

SUGGESTED MANNING

1. The following is a suggested manning for an Army team tasked to widen channels at Atafu and Fakaofo:

a. one x officer;

b. one x Senior Non Commissioned Officer (SNCO);

c. one x Junior NCO';

d. five x Field Engineers (to include three x divers for reef edge inspections and one x person qualfied in First Aid);

e. one x cook;

f. one x vehicle mechanic.

ANNEX Q TO
TOKELAU RECON REPORT
DATED 10 MAY 85

EXPLOSIVE COSTING

1. The costing for explosives required is as follows and is costed at Government Stores Board prices:

a. Molanite Explosive (4298 carts) = 2905 kg
40 mm dia, (31 Dec 84) @ $79.22 per 25 kg = $9205.36

b. Flexicord = 10155 m
(31 Dec 84) @ $161.99 per 334 m coil = $4925.18

c. Detonators.
Electric No 8/1.8 metre aluminum = 82
(31 Dec 84) @ $97.14 per 100
say 100 = $97.14

d. DCR.
15, 25, 35 and 45 milliseconds = 407
(31 Dec 84) @ $2.83 each
102 of each DRC so say 408 = $1154.64

e. Shot Firing Cable 600 m
(16 Feb 84) @ $27.20 per 100 m coil = $163.20

f. Desirable Purchases.
Atlas Galvonmeter = $243.99
(16 Feb 84)
Nissan 30 shot = $421.47
(16 Feb 84)

Total cost for explosives = $15545.52

(including sub-para f., = $16210.98)

ANNEX R TO
TOKELAU RECON REPORT
DATED 10 MAY 85

ROL REQUIRED AND COSTING

1. The following is an approximate POL expenditure calculation using the hourly rates shown:

a. 375 CFM compressor @ 15 l/hr
(diesel @ $0.5304/l)
usage
= 222 hours
= 3330 l
= $ 1766.23

b. 6.5 KVA generator @ 3.5 l/hr (petrol)
(petrol @ $0.8559/l)
assume usage of 14 hrs/day x 152 days
= 2128 hours
= 7448 l
= $ 6374.74

c. Outboard motor 40 hp @ 18 l/hr
(Petrol 2-stroke)
(petrol @ $0.8559/l) mixture 1:50
(oil 2-stroke @ $1.3654/l)
assume usage of 6 hrs/week for 22 weeks
= 132 hrs
= 23761
= $ 64.86 oil
= $ 1986.11 petrol
= $ 2050.97

Total POL expenditure = $10191.94

ENCLOSURE 2 TO
TOKELAU RECON REPORT
DATED 10 MAY 85

SCHLAGE
Part of worldwide Ingersoll-Rand

Schlage (N.Z.) Limited

Head Office:
437 Rosebank Road,
P.O. Box 19-347
Avondale, Auckland
New Zealand.
Telephone 885-096 Telex NZ 21491

10 May 1985

Ministry of Defence
Army Department
25 Engineer Support Squadron
Linton Camp
PALMERSTON NORTH

ATTENTION : LIEUTENANT A.M. SKINNER

Dear Sir

TOKELAU ISLAND PROJECT   OUR REFERENCE : NZ8348/85

In reply to your letter of 17 April 1985 and our meeting recently, I have enclosed herewith details of the equipment we discussed.

It would be impossible in my mind to use hand-held jack hammers, as used on the previous project, under the conditions you will experience; due mainly to the tidal situations and the terrain you will encounter. For this reason, we suggest the use of a light mounted crawlair rig. This will give you flexibility to traverse the unit across the coral reef and will speed up the operation to enable you to meet the project deadline. It will also enable a much cleaner drilling technique with little or no plaining of the finished channel walls.

The portable compressor can be installed on the shore and air piped across the reef to the rig, thus alleviating the need to drag the compressor through the surf. For this, we suggest using a galvanised pipe to take the air supply to within 50' or so from the drill rig. We have included pricing for this pipe in our offer.

The various sections enclosed deal with performance and output potential, description of rig, engineering data and pricing. Hopefully, these will enable you to fully evaluate the project.

We would welcome the opportunity to further discuss this project and our offer with you.

Yours faithfully
SCHLAGE (NZ) LIMITED

Chris

(C.J. Benny)
IR SALES MANAGER

ENCLOSURE 2 TO
TOKELAU RECON REPORT
DATED 10 MAY 85

SCHLAGE
Part of worldwide Ingersoll-Rand

Schlage (N.Z.) Limited

Head Office
437 Rosebank Road,
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Avondale, Auckland
New Zealand
Telephone 888-006 Telex NZ 21491

10 May 1985

Ministry of Defence
Army Department
25 Engineer Support Squadron
Linton Camp
PALMERSTON NORTH

ATTENTION : LIEUTENANT A.M. SKINNER

Dear Sir

TOKELAU ISLAND PROJECT   OUR REFERENCE : NZ8568/85

In reply to your letter of 17 April 1985 and our meeting recently, I have enclosed herewith details of the equipment we discussed.

It would be impossible in my mind to use hand-held jack hammers, as used on the previous project, under the conditions you will experience; due mainly to the tidal situations and the terrain you will encounter. For this reason, we suggest the use of a light mounted crawlair rig. This will give you flexibility to traverse the unit across the coral reef and will speed up the operation to enable you to meet the project deadline. It will also enable a much cleaner drilling technique with little or no plaining of the finished channel walls.

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Yours faithfully
SCHLAGE (NZ) LIMITED

(C.J. Denny)
IR SALES MANAGER

TITLE

SECTION

SECTION 1 : GENERAL DESCRIPTION AND SPECIFICATION

INGERSOLL-RAND LM100 CRAWLAIR DRILL RIG

The LM100 drilling rig is a track mounted, air powered, self-propelled, rock drilling unit. The tracks are driven by powerful air propelling motors, also incorporating a 1300 psig hydraulic system, heavy duty boom, and a drill guide for 10 feet drill steel changes, that supports the Ingersoll-Rand drifter drill.

It is designed to tow its own compressor by means of a tow hitch mounted to the rear centre of the main frame.

Attached is a more detailed set of specifications for the drill rig.

GENERAL DESCRIPTION & SPECIFICATIONS
OF
LM100 CRAWLAIR DRILLING RIG

DESCRIPTION

The LM100 Crawlair Drilling Rig is a track mounted, air operated, self-propelled, rock drilling unit with powerful, air driven propelling motors; a 1300 psi hydraulic system; a heavy duty boom; and a drill guide for 10 ft. steel change, which will support a drifter or a downhole drill to meet various drilling conditions.

The LM100 is a compact, powerful unit designed to drill 1-3/4 in. (44mm) through 2-1/2 in. (64mm) holes with the YD90 Drifter, and 3-3/8 in. (85mm) through 3-1/2 in. (90mm) holes with a rotary head and the DHD09 Downhole Drill. It is capable of drilling vertical to horizontal blastholes, and is recommended for shaft sinking, rock splitting, trench work, sewer construction and bridge demolition.

The LM100 is a pioneering drill rig, capable of climbing steep grades over rough terrain. Its low stance and compact design enables it to work well in tight quarters.

The lifting eye located on the boom allows balanced hoisting for positioning the machine on the job or on your trailer.

GENERAL SPECIFICATIONS	ENGLISH	(METRIC)
Weight (with Drifter)	5,400 lb.	(2,450 kg)
Overall Length (guide horizontal)	12'8"	(3,850mm)
Overall Width	5'9"	(1,750mm)
Overall Height (boom vertical)	15'8"	(4,770mm)
(less boom)	3'11"	(1,200mm)
Width of Grouser	8"	(204mm)
Ground Clearance	9"	(230mm)
Track Oscillation	20°	(20°)
Boom Movement:		
Above Centerline	45°	(45°)
Below Centerline	30°	(30°)
Swing Range	90°	(90°)
Guide Movement:		
Swing	90°	(90°)
Dump	75°	(75°)
Tramming Speed	1.8 MPH	3 km/hr
Climbing Ability	35° grade	(35°)
Propelling Air Motor	7 HP	
Drawbar Pull	3,100 lb.	(1,400 kg)
Travel Speed	0-1.8 MPH	

OPTIONAL EQUIPMENT

1. Vaposol Dust Control System - The Vaposol system is an improved method of damp drilling, developed for use on track-mounted rock drilling rigs to reduce the health hazards caused by inhalation of rock drill dust particles during drilling operations.

2. Dust Collector System - The dust collector system is a dry, fan-induced draft, pulse jet, self-cleaning unit designed to draw dust and rock cuttings away from the hole and deposit them on the ground away from the operator. The air consumption required to drive the suction fan is 90-100 psi.

3. Downhole Drill Package - The YD90 Drifter can be removed in favor of the ZD45 rotary head. This light-weight rotary head is powered by a 4 HP reversible air motor, designed to provide independent rotation for the DHD09 downhole drill. The DHD09 is a hammer drill which is capable of drilling 3-3/8" - 3-1/2" holes using less air.

MAIN FRAME

The main frame is a rugged steel fabrication, which is the mounting base for various assemblies of the LM100. A hydraulic reservoir is mounted on the rear center of the main frame, with the air line lubricator mounted directly to the left.

A tow hitch is mounted to the rear center of the main frame which enables the drill to pull along a portable compressor. It can also be used to pull the drill with a primary mover over very rough terrain.

All controls for boom movement are located directly behind the machine near the tram controls for ease of set-up when tramming from hole to hole.

A 1.5 HP vane type air motor drives a hydraulic pump which supplies power for the various drilling functions. The motor and pump are mounted on the left hand strut, between the two track assemblies. The system operates at 1300 PSI. This low pressure system ensures long component life, and cuts down costs on hoses and fittings.

Drill controls can be mounted on the drill guide or on the hydraulic boom control console at the side of the drill. The rear mount is used when two men are mandatory on the job site.

UNDERCARRIAGE

The undercarriage consists of a right and left hand track assembly. Each track is driven by an independently controlled, reversible air motor. These are piston air motors with 7 HP each to supply power for towing a compressor and climbing steep grades.

The LM100 has a maximum of 20^{o} oscillation. This is accomplished through heavy duty struts welded to the track assembly and hinged under the main frame.

The braking system is mechanical with positive engagement, which is a safety feature. A declutching device allows the brake to be disengaged when the crawlair is being towed. Each assembly has 5 rollers for even wear on the chains which support " grousers. The track tension is easily adjusted by tightening the adjusting spring

BOOM

The boom assembly consists of a round tube with a forked clevis welded to each end; a lift cylinder; a swing cylinder; and the attaching components.

The rear clevis of the boom is attached by a pedestal to the boom base clevis on the main frame. This attachment produces a universal joint which permits a coverage of 45° right or left of centerline and 45° above 30° below the horizontal centerline. The clevis at the front end of the boom supports the dump and swing assembly.

The swing cylinder is attached at its piston end, to the side of the boom, by a swing clevis, pin, and a welded clevis on the boom. The blind end of the cylinder is attached to a pedestal which is pinned to the boom base clevis on the main frame.

The lift cylinder is located underneath the boom. Its piston end is attached toward the front of the boom through a swing clevis pinned to a clevis welded on the bottomside of the boom. The blind end of the cylinder is pinned to a clevis welded at the center of the main frame cross member.

A lifting bail is welded on the top side of the boom, which allows machine to be positioned in confined areas.

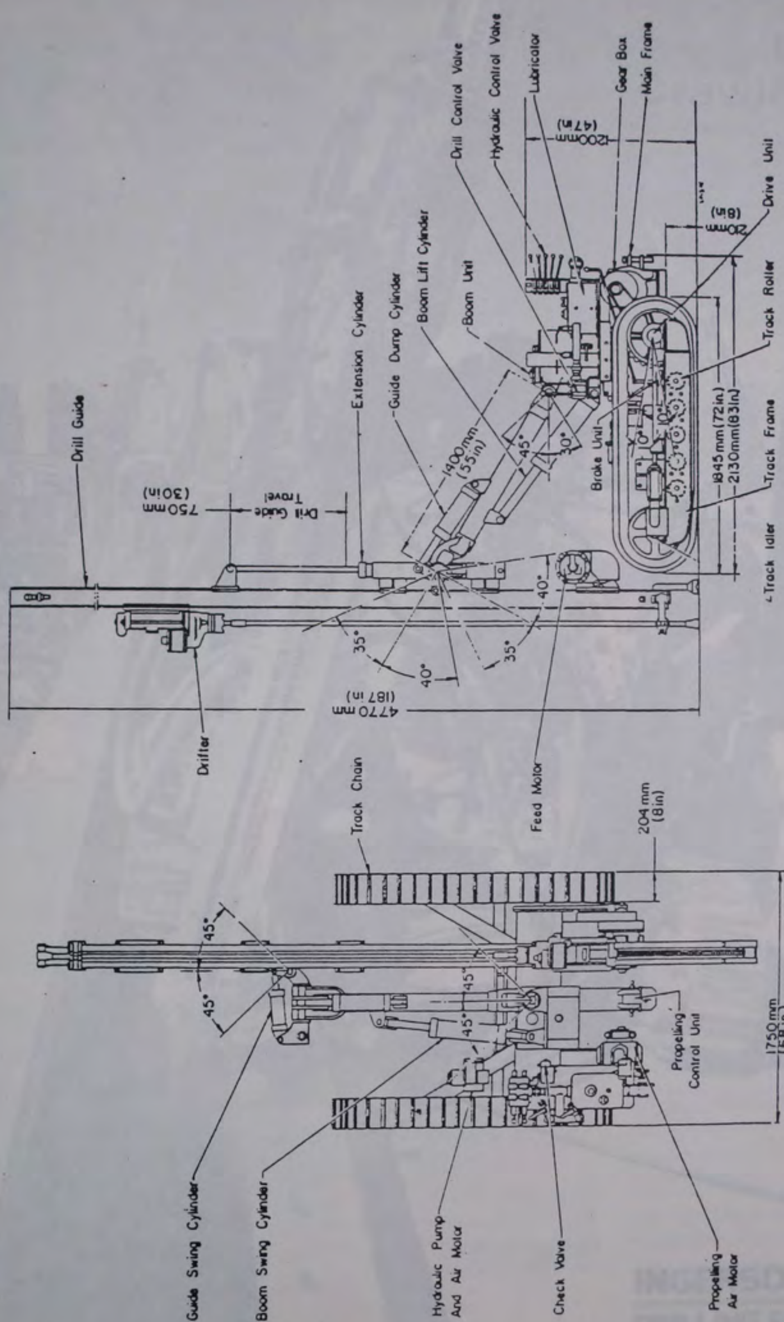
DRILL GUIDE & MOUNTING

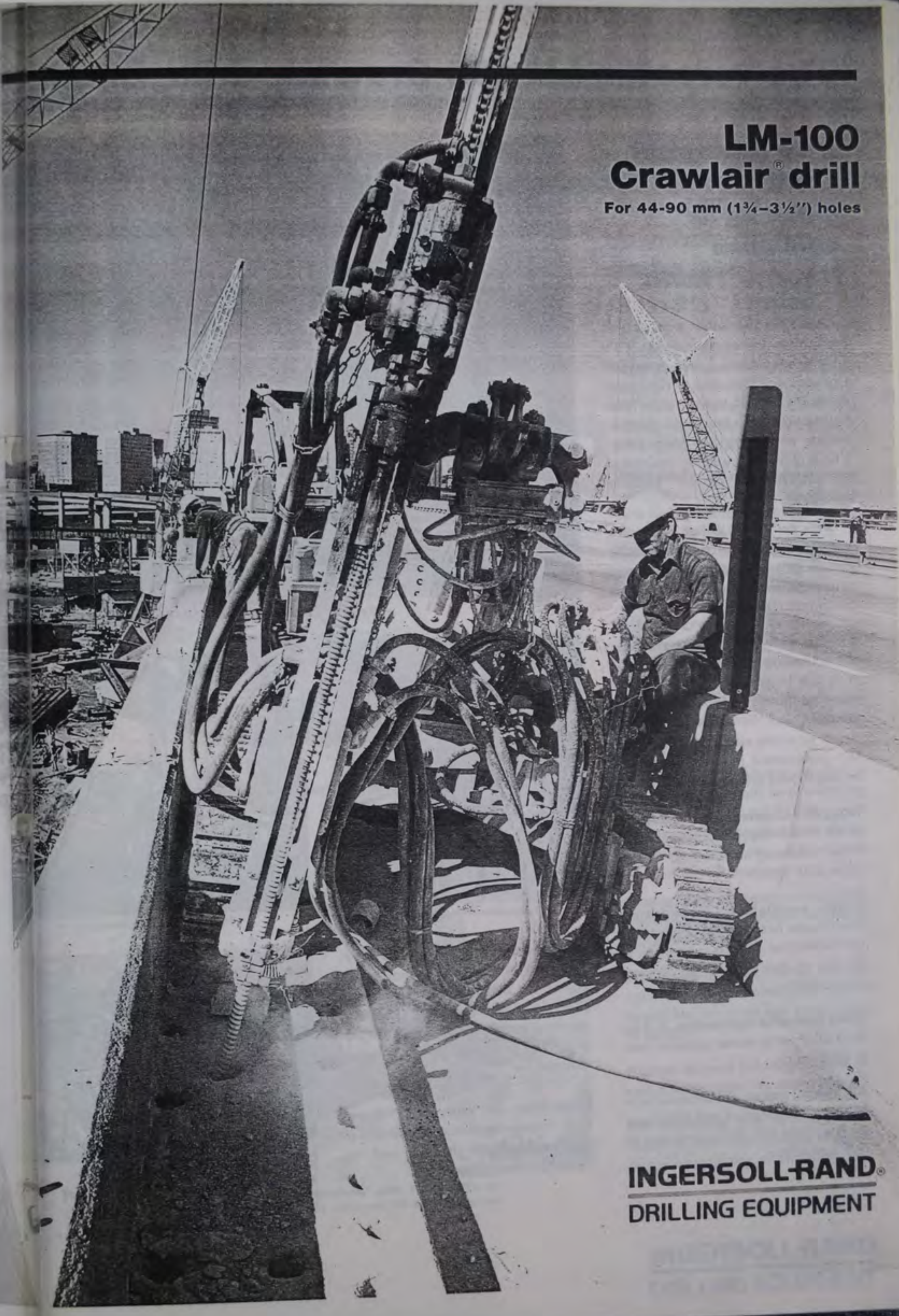
The drill guide is constructed of 4" steel channel. The guide is equipped with a latch type centralizer which is bolted to the drill guide, and a heavy duty footpiece is welded to the base of the guide below the centralizer. Feed pressure for the drifter is supplied by a 3 HP, five cylinder piston air motor, mounted on the bottom back side of the guide.

The drill guide is supported by guide extension mounting which in turn is supported by the dump and swing assembly. The extension mounting is designed to extend the drill guide for additional coverage and to plant the footpiece firmly against the drilling surface for added stability.

The dump and swing assembly is a hydraulically powered drill guide positioning device, supported at the front end of the boom. The assembly permits a full 180° drill guide dump (end over end rotation) and 85° drill guide swing (50° left, 35° right).

LM100 CRAWLAIR® MOUNTING




LM-100
Crawlair® drill
For 44-90 mm (1¾–3½") holes
INGERSOLL-RAND®
DRILLING EQUIPMENT

The versatile LM-100 Crawlair drill. Small in

It's a lightweight energy-saving drifter rig for 44-64 mm (1¾-2½") holes.

Don't let the small size of this husky little drilling rig fool you. It's a fully-mechanized, self-propelled Crawlair drill that does all the heavy work for you. It trams easily from hole to hole at the touch of a throttle, towing a portable air compressor. The drill tower is quickly positioned by effortless hydraulic cylinder operation.

With the YD-90 drifter, it handles a 3048 mm (10') rod change, with 32 mm (1.25") rods, threaded bits and couplings, to depths 12 m (40') at maximum efficiency.

Simple, safe one-man operation. All tramming and positioning controls are located at the rear of the machine for easy operation. Drilling controls, can be mounted on the tower or at the side of the machine, for convenience in either deep-hole or single-pass drilling.

Rugged crawler construction. With two independently-controlled 7-hp tramming-air motors, it can climb a 35° grade.

Track oscillation. Heavy steel main frame has walking-beam track oscillation that permits each track to tilt up or down to match ground irregularities.

More powerful hydraulics. A 3-hp hydraulic pump motor assures faster positioning.

Air and oil gages. Continuous indication of air pressure and lubricator oil level take the guesswork out of drill operation.

Works well in close quarters.

Independent-rotation drifter.

Lifts easily for shaft sinking.

Independent rotation drifter. The YD-90 air drifter has ample power for drilling holes to 64 mm (2½") in diameter. Integral air motor drive provides independent rotation with infinitely variable speed control.

Uses little air. With a P425 Spiro-Flo® compressor, there's plenty of air to operate the drill, rig and optional dry dust collector.

Rough terrain is no problem.

n performance.

Exhaust and impact noise go right down the hole with the bit.

The AT-480 dust collector, available with YD-90 drifter or DHD-09 Down-hole drill, uses only 2 m^3/min (70 cfm) of 7 kg/cm^2 (100 psi) air.

It's a low-noi deep-drilling downhole rig 85-90 mm (3⅜-3½") h

Equipped with a rot larger centralizer, the I you all the Crawlair b the basic advantages drilling—with the In DHD-09 Downhole dri

Drills faster on deep h penetration rate doesn' each rod added to the s

Uses less air because does double duty, pow and then cleaning the h

Drills straighter b Downhole drill is less ea off-course by varying s

Extends rod life becau forces are transmitted drill rod.

The DHD-09 Dow engineered and built t performance at rock- Penetration is proporti pressure across the these other I-R feature

Stop-action plunger stops the hammer acti the drill is raised.

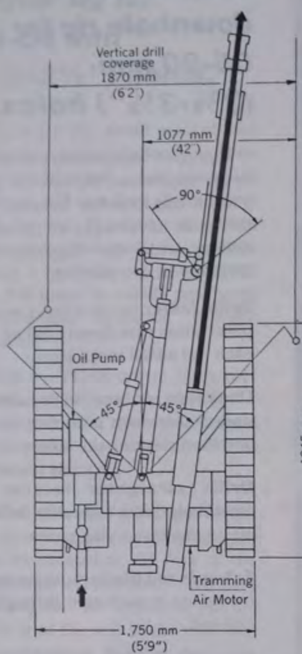
Wear sleeve surroun cylinder can be revers sleeve life. It's easy an to replace.

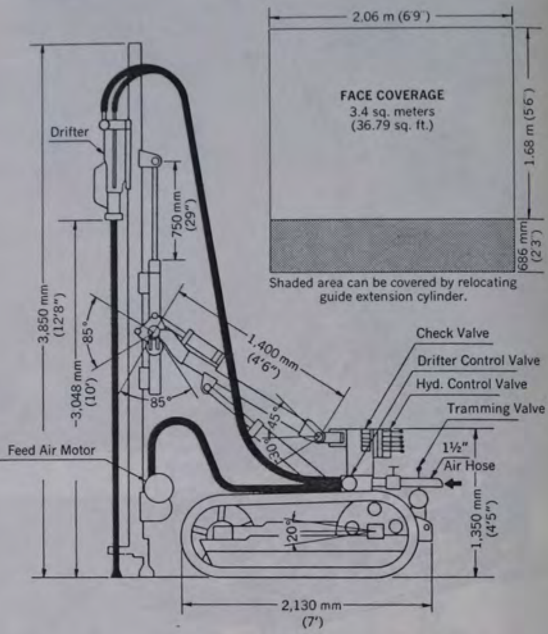
Piston delivers full im rectly on the bit at any

Bit retaining key p dental dropout yet per moval for grinding or r

INGERSOLL
DRILLING EQ

LM-100 Crawlair drill specifications





Dimensions		
Overall length (tower horiz.)	3850 mm	12'8"
Height (tower horiz.)	1350 mm	4'5"
Overall width	1750 mm	5'9"
Ground clearance	230 mm	9"
Track width	204 mm	8"
Track length	1845 mm	6'⅝"
Track oscillation	20°	20°
Positioning		
Boom lift	45° up, 30° down	
Boom swing	45° right, 45° left	
Guide swing (horizontal)	45° right, 45° left	
Guide dump	85° (two positions)	
Tramming		
Air motors	Two 7-hp (one per track)	
Tramming speed	0 to 2.6 kph	0 to 1.6 mph
Climbing ability	35° grade	35° grade
Drawbar pull	1400 kg	3100 lb

Drilling Range		
Hole diameter (YD-90)	44-64 mm	1¾-2½"
Hole diameter (DHD-09)	85-90 mm	3⅜-3½"
Rod diameter	32 mm round	1¼" round
Rod length	3048 mm	10'0"
Drilling range width	2050 mm	6'9"
Horizontal height, maximum	2350 mm	7'8½"
Horizontal height, minimum	680 mm	2'2¾"
Hydraulic Pump Air Motor		3 hp
Total Weight*	2450 kg	5400 lb
Recommended Air Compressor		
	12 m^3/min at kg/cm^2	425 cfm at 100 psi

*With YD-90 drifter.

Model YD-90 Drifter		
Bore and stroke	90 × 85 mm	3½ × 3⅜"
Blows per minute	1600	
Rotation	0 to 150 rpm	
Weight	85 kg	187 lb
Model DHD-09 Downhole Drill		
Weight (less bit)	24 kg	53 lb
Length (bit extended)	965 mm	35.6"
Outside diameter	76 mm	3"
Bit diameters	85 mm 90 mm	3⅜" 3½"
Air usage	3.5 m^3/min at 7 kg/cm^2	125 cfm at 100 psi
ZD45 Rotary Head		
Max. torque	79.5 kg-m	575 ft-lb
RPM range	0-65	
Horsepower	4.0 max	
Air usage at 25 rpm	3.4 m^3/min	120 cfm
Weight	91 kg	200 lb

Ingersoll-Rand Company
Rock Drill Division
Phillipsburg, New Jersey 08865

INGERSOLL-RAND®
DRILLING EQUIPMENT

Form 4466-A ©1977, 1981 Ingersoll-Rand Co. Printed in U.S.A.

SECTION 2 : DRIFTER DRILL SPECIFICATIONS

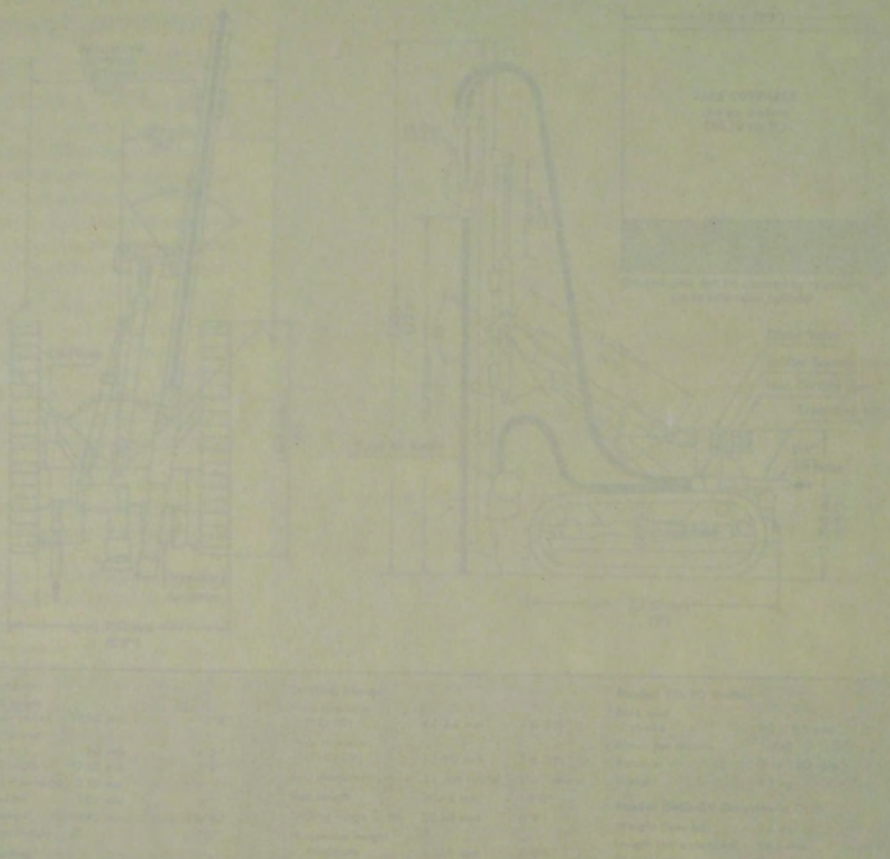
INGERSOLL-RAND [illegible] DRIFTER DRILL

The [illegible] air drifter has ample power for drilling holes to [illegible] (2½") in diameter. Integral air motor drive provides independent rotation for infinitely variable speed control.

For shot holes, in holes up to 30' in depth, a [illegible] pneumatic compressor has plenty of air to operate the drill. It handles [illegible] (10') rod changes, with [illegible] rods, threaded bits and couplings.

Attached is a more detailed specification of the drifter.

LM-100 Crawlair drill specifications



Ingersoll-Rand Company
Rock Drill Division
Phillipsburg, New Jersey 08865

INGERSOLL-RAN
DRILLING EQUIPM

SECTION 2 : DRIFTER DRILL SPECIFICATION

INGERSOLL-RAND YD90 DRIFTER DRILL

The YD90 air drifter has ample power for drilling holes to 64mm (2½") in diameter. Integral air motor drive provides independant rotation for infinitely variable speed control.

For short holes; ie holes up to 30' in depth, a P375SD Spiro-flo compressor has plenty of air to operate the drill. It handles 3.048m (10') rod change, with 32mm (1.25") rods, threaded bits and couplings.

Attached is a more detailed specification of the drifter.

GENERAL DESCRIPTION AND SPECIFICATIONS OF YD90 DRIFTER

DESCRIPTION

The YD90 drill is a 3.5" (90mm) bore, valveless, pneumatic hammer drill that incorporates an independently controlled, gear type, air powered rotation motor to rotate the drill steel and bit.

The YD90 drill is recommended for use on the LM100 self-propelled mountings, and for surface applications with feed chain mountings on any type of fixed or mobile drilling rig. It is capable of drilling 1.75" (45mm) to 2.5" (62mm) diameter holes in all types of rock formations.

The YD90 is designed with an independently controlled, air powered, gear type rotation motor that provides continuous drill steel rotation - forward and reverse. This heavy duty motor is mounted on the top of the drive gear cover at the lower end of the drill. The motor drive gear and idler gear convert the force of the operating air to rotation power. The rotation power developed by these gears is transmitted through a drive gear shaft to the chuck drive intermittent gear and then into the drill steel and bit. The drive shaft serves as a torsion bar which absorbs energy and prevents damage to the motor drive gear teeth if the drill steel gets hung up or stuck.

The air required to operate the drill is dependent on the pressure at the drill main air inlet. The cylinder houses the air valve piston, and piston stem bearing. It includes main air front supply ports, exhaust port, and vent ports which direct lubricated air onto the drill mounting feed chain. Ports in the air distributor body (and the bronze liner) direct the main operating air through the front and rear piston supply ports. Three oil rings, cut in the piston head, act as small oil reservoirs which deposit a film of lubrication between the piston head and the cylinder wall.

The final air requirements for the YD90 passes through the hollow drill string and is used to blow the cuttings out of the hole. The amount of air consumed depends on the pressure at the blow inlet in the backhead, and the number of steels in the drill string. In uniform rock formations, improved drill performance can be obtained by throttling back excess blow air and diverting additional air to the hammer, so that the drill runs at a high pressure.

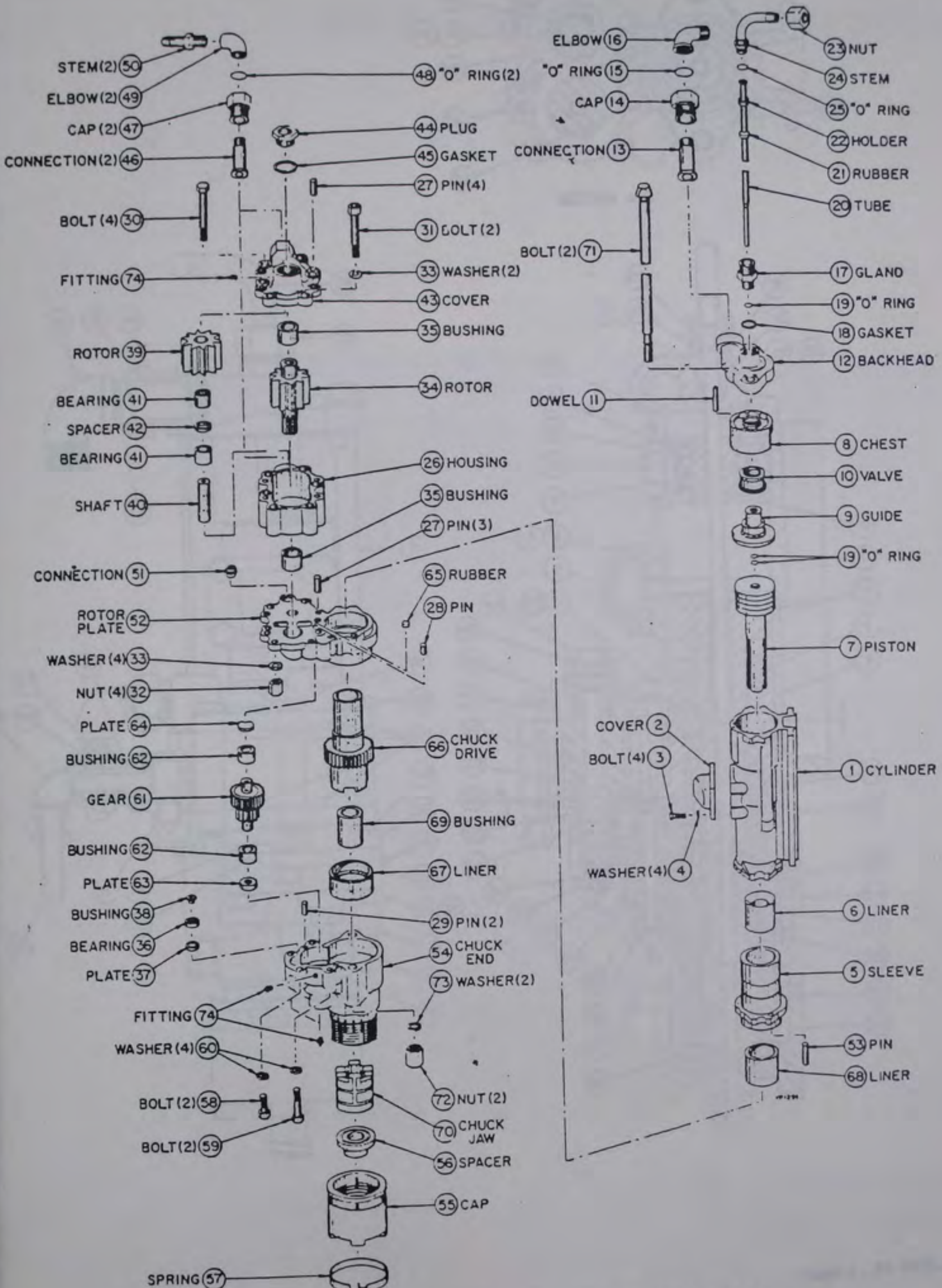
An air line lubricator must be used with the YD90 drifter, all moving parts of the drill are lubricated by the oil-laden operating air which is directed to all critical points. When the drill is used on a "Crawlair" mounting, a lubricating oil reservoir is built into the main frame.

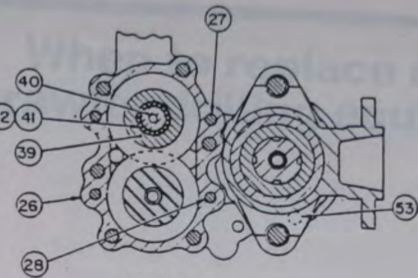
.../2

SPECIFICATIONS

DRILL SPECIFICATIONS	ENGLISH	METRIC
Net Weight of Drill	187 lbs	(85 kg)
Bore of Cylinder	3.5 ins	(90 mm)
Working Stroke	3.5 ins	(90 mm)
Size of Main Air Inlet Hose Required	1.5 ins	(38 mm)
Size of Blower Hose Required	1 in	(25 mm)
Air Consumption at 100 psig (7 bar)	368 cfm	(10.3 m3/min)
Blows per Minute	1600	

YD90
INDEPENDENT ROTATION DRILL

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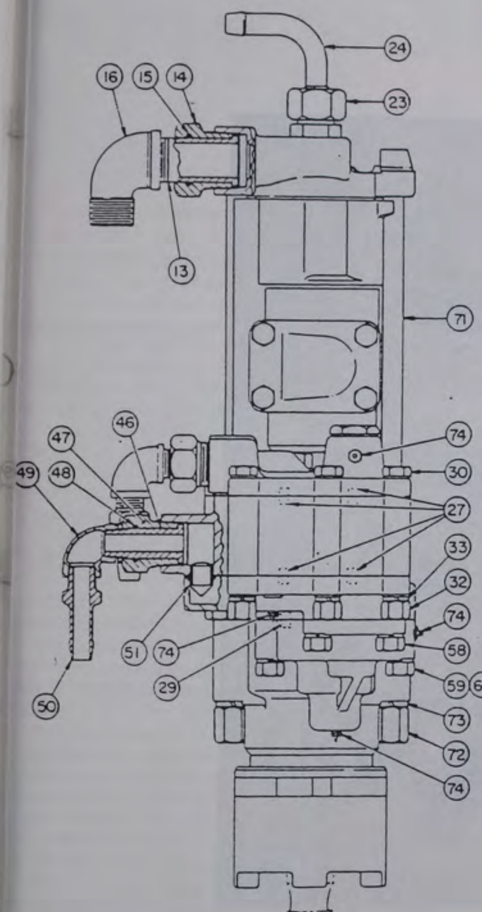
SECTION A-A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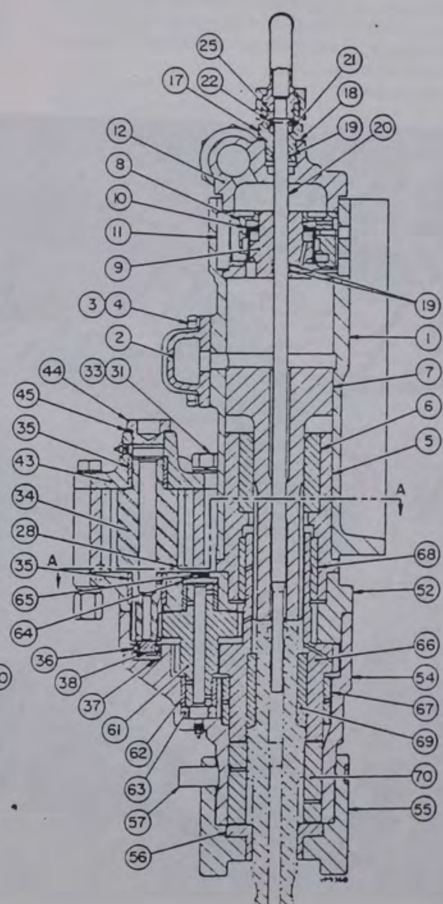
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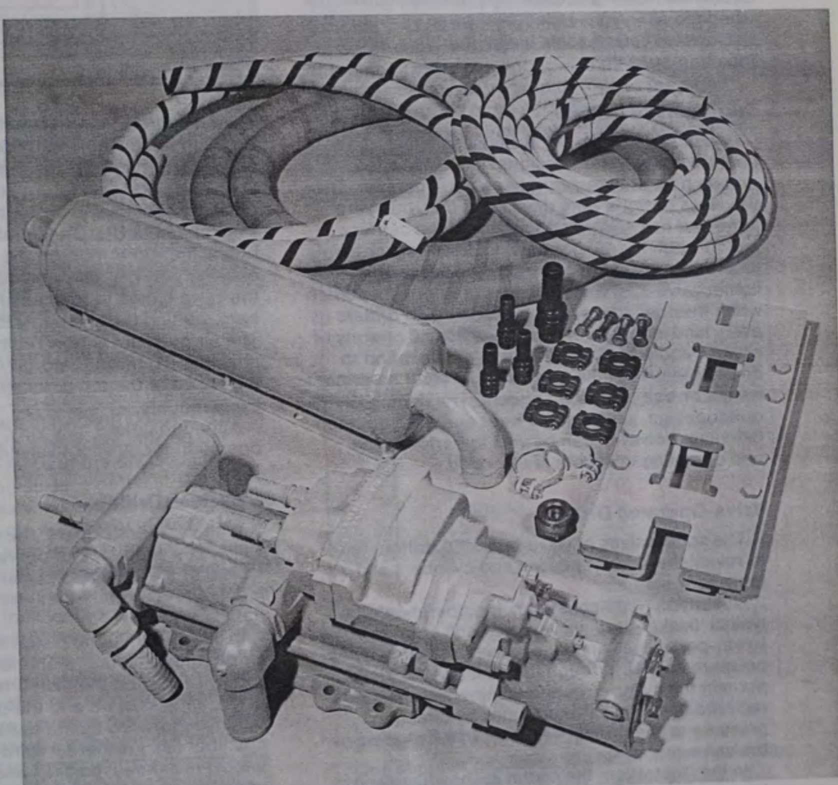
When to replace drifters on crawler drilling equipment



INGERSOLL-RAND®
DRILLING EQUIPMENT

When to replace drifters on crawler drilling equipment

The question of whether to rebuild or replace equipment as it wears in service has always been complicated by an almost infinite variety of qualifications. Most decisions are made on the basis of costs—to repair equipment at an early stage in its working life; or to keep the equipment working, although at lower efficiency, until it can operate no longer. In the latter case, a prolonged period of operation at low productivity may be more costly than initial rebuilding.

With the drifter units mounted on crawler drilling equipment, there are some very definite indications when rebuilding is needed, and some very potent reasons to replace some types of drifters rather than to rebuild them.

Two Types of Drifters

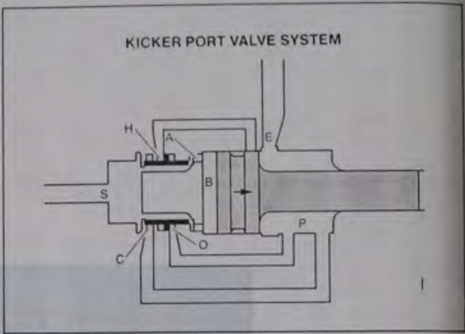
Pneumatic drifters are available in either valve-operated or valveless designs. Valve-operated drifters had, until recently, been more popular. The valveless designs were developed first, but were large and heavy. Around the turn of the century, and through the 1920's, moving drills from one hole to another was done manually. Therefore, the lighter valve-operated drills won greater acceptance when they became available. Today, with drifters of every kind mounted on hydraulic booms or arms of crawler equipment, moving from one location to another requires little or no manual labor so drifter weight or size is of little concern. The complexity of drifter design, sensitivity to wear and ease of reconditioning, however, can be vital to performance and operating costs of crawler drills.

Valve-Operated Drifters

The spool valves of valve-operated drifters tend to reveal the wear of pistons and cylinders at a fairly early stage.

Illustration (I) demonstrates the operation of a typical "kicker-port" valved rock drill or drifter. The kicker-port valves are spool valves activated by air pressure applied through the passages or kicker-ports in the cylinder, opened by the piston as it reciprocates. The valve operates by directing pressure to the front or rear side of a flange on the valve.

In the illustration, the piston is shown moving forward, on a power stroke with compressed air (S) passing through ports (A) to the back chamber (B). Just before the piston reaches exhaust port (E), it uncovers a kicker port that directs air through another passage to the back side of valve flange (H). This snaps the valve forward to shut off air flow to the back chamber (B). Immediately afterwards,



exhaust port (E) opens and the back chamber (B) drops to nearly atmospheric pressure.

The piston now strikes the striking bar and drill steel and begins its return stroke driven by air pressure still flowing through port (C), into the front chamber (P). On the return stroke the piston opens the kicker-port on the forward side of exhaust port (E). This admits air to the front side of the valve flange at (O) causing the valve to shift back, cutting the air supply to the front chamber (P). The air pressure is now redirected to the back chamber (B) through ports (A). This air cushions the piston at the top of its stroke and the cycle repeats.

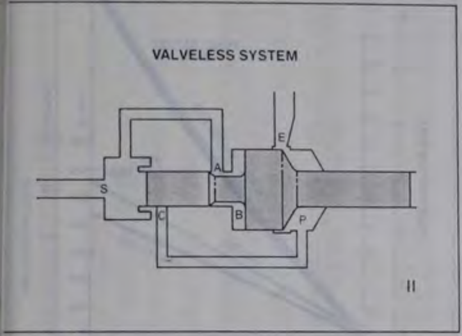
Although details may vary, this is the principle of operation for all spool-valve-operated drifters.

Valveless Drifters

With valveless drifters, the piston acts as its own valve. The sequence of operation following, is typical of the valveless drifters produced by Ingersoll-Rand and other manufacturers although details may differ.

In illustration II, the piston is driven forward by air passing the "tail" diameter at (A) from the air supply (S). When the piston tail closes the ports at (A), air is shut off and the piston continues to be driven forward by the expansion of air in back chamber (B). Further forward the piston head uncovers exhaust port (E) and the piston tail uncovers the front chamber ports at (C).

The piston delivers its blow to the striking bar and begins its return stroke, driven by air flowing to front chamber (P) through (C). When the returning piston tail covers ports (C), air flow to (P) is discontinued but the piston is still driven back by the expansion of the air in chamber (P). A little further back the piston head uncovers the front edge of



exhaust port (E) and the piston tail opens the back-chamber air supply at ports (A). This air cushions the piston at the end of its return stroke and starts a new cycle.

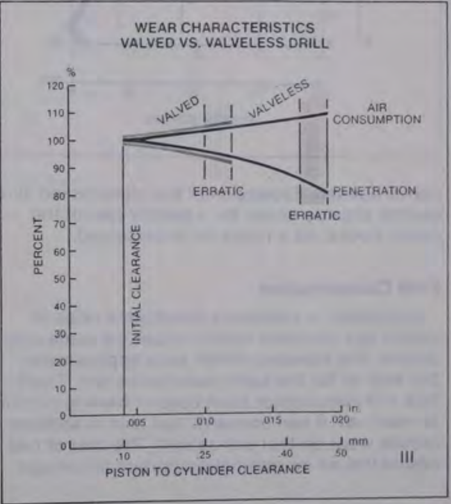
Symptoms of Wear

The use of a good rock-drill oil injected into the compressed air that drives the drifter, delivered at a constant rate, will minimize wear and lengthen working life. However, all mechanical things wear out eventually. With drifters, the bushings or bearings that support the piston will be one of the areas most subject to wear. The piston and the cylinder will wear where they are in running contact. The part of the piston which strikes the striking bar delivering percussive force to the drill steel will show wear. The mating surface of the striking bar and the threads that join the drill steel are designed to withstand the impacts necessary to drill three to five thousand feet of hole in hardrock before being replaced. And of course, the valve in valve-operated drifters will manifest symptoms of wear. With valve-operated drifters, as the clearance between the piston and cylinder increases, air can escape past the piston and trip the spool valve prematurely, causing erratic performance. Before that happens, there will be a noticeable reduction in penetration rate. If an air pressure gauge is placed at the inlet for the drifter, it will show a substantial drop in pressure, compared to a new unit. By the time the wear or clearance between piston and cylinder reaches .25mm (.0097 in.) the drifter will be virtually inoperable.

With valveless drifters, as wear progresses, there will be a drop in pressure as air escapes past the piston, and a noticeable reduction in penetration rate will occur. However, since there is no spool valve involved, the valveless drifter can continue to operate much longer—until clearance between piston and cylinder approaches .45mm (.0175 in.).

Replacement is More Economical

With both types of drifter, at this point a decision must be made whether to rebuild or replace. As can be seen, the valveless drifter is a simple design and, therefore, easier to rebuild. In addition to its greater tolerance to wear between piston and cylinder, it has another advantage. The piston is supported by two widely spaced bearings or bushings. This minimizes contact wear between the cylinder and piston, and helps reduce bearing wear as well. For all practical purposes, this means that this type of valveless drifter will operate significantly longer than valve-operated drifters in the same service. It can be more economical to replace valved drifters with valveless designs, rather than rebuild them.

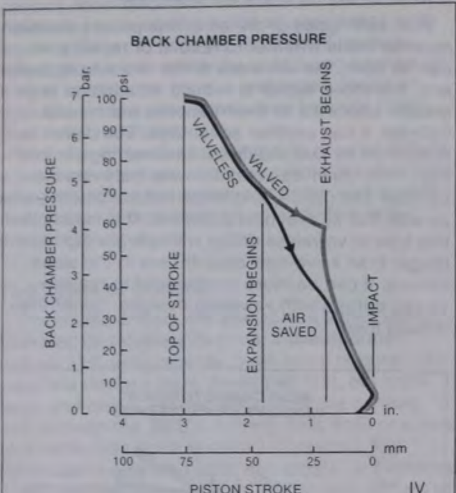


Ingersoll-Rand Valveless Drifters

One supplier produces valveless drifters suitable for operation on virtually any crawler drilling rig. The Ingersoll-Rand VL-120, designed to drill holes from 2½ to 3½ inches in diameter (64-89mm) and the VL-140 valveless drifter for holes from 2½ to 4 inches (64-102mm), both provide penetration rates at least equal to original equipment, and at reduced air consumption.

Operating Advantages

Valveless drifters have several operating advantages. First, they require less compressed air. Illustration IV compares the pressure in the back chamber of valved and valveless drifters. Pressure in a valved drifter is supplied continually, until just before the valve is tripped or just before the exhaust port is opened. Pressure in the back chamber of a valveless drifter is cut off long before the exhaust



IV

port is opened. Expansion of the compressed air is used to provide power for a greater part of the piston stroke. As a result air is conserved.

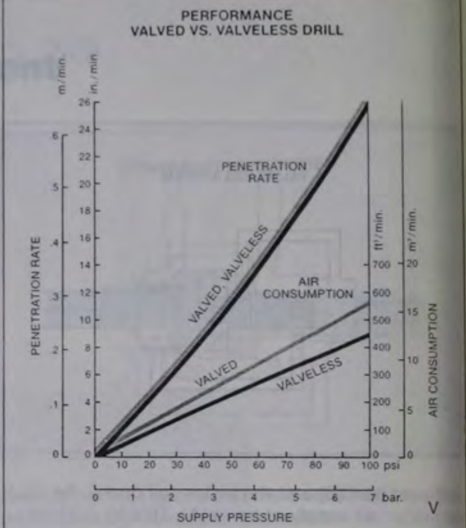
Fuel Conservation

Illustration V compares penetration rates of valved and valveless drifters under the same conditions. The valveless drifter uses approximately 3m³ less air for the same penetration rate. Therefore, the compressor plant doesn't have to produce as much air. It can conserve fuel, and in addition, reduce wear on that unit as well. The cost of fuel makes this an increasingly important advantage.

Low Noise

Further advantages resulting from the use of air expansion during piston travel are that there is less noise, and less tendency to "diesel" when the drifter is run as the drill steel is withdrawn from the hole. The dieseling phenomenon occurs when the lubricating oil entrained in the compressed air ignites due to high pressures developed in the front chamber of the drifter. Because of the improved piston support in valveless drifters, lubrication is less critical and less oil can be used. Less oil produces less oil fog in the exhaust; a consideration for operator comfort and health.

From the viewpoint of maintenance and operating costs, it is apparent that it will pay to replace valve-operated drifters with valveless designs rather than rebuild the former.



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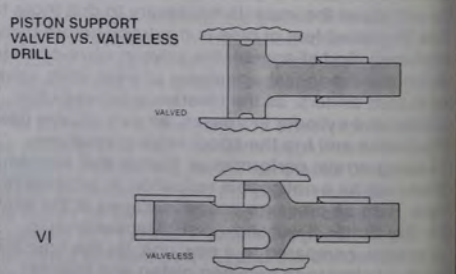


VI

Ingersoll-Rand Co.
Rock Drill Division
Phillipsburg, N.J. 08865

INGERSOLL-RAND
DRILLING EQUIPMENT

SECTION 5 : PORTABLE AND [illegible] [illegible]

[illegible]

The P375WD is a single stage oil flooded, rotary screw air compressor. The air compressor is driven by the [illegible] engine through a flexible coupling [illegible] part load fuel economy.

It is capable of delivering 375 cfm [illegible] of free air at 100 psig (7 bar) pressure, at [illegible]. Maximum 125 psig (8.6 bar). [illegible] oil separator.

The diesel engine is an in-line air cooled [illegible] Model F6L912, delivering 112 hp at a rated speed of [illegible] idle speed is 1600 rpm. It is equipped with 12 volt electric starter.

[illegible] with the unit are the following safety features:

1. Automatic engine shutdown in the event of:

   (a) High air discharge temperature

   (b) Low engine oil pressure

   (c) High engine exhaust temperature

   (d) Low engine coolant level

2. Automatic blowdown valve.

3. Safety valve.

4. Minimum pressure valve.

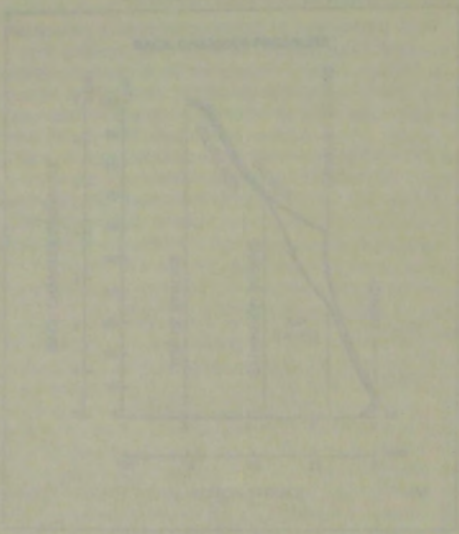
5. Air filter restriction indicator.

The complete assembly is mounted on [illegible] wheels on a welded steel frame. The [illegible] is supported on torsion bar suspension on a single axle, [illegible]. Parking brakes and lifting bail is standard. The canopy enclosing the package is sheet steel with [illegible] doors for complete accessibility.

Enclosed are [illegible] compressor.

Operating Advantages

Valveless drifters have several operating advantages. First, they require less compressed air. This [illegible] compares the pressure in the back chamber of valved and valveless drifters. Pressure in a valved drifter is supplied continually, until just before the valve is tripped or just before the exhaust port is opened. Pressure in the back chamber of a valveless drifter is cut off long before the exhaust



port is opened. Expansion of the compressed air is used to provide power for a greater part of the piston stroke. As a result air is conserved.

Fuel Conservation

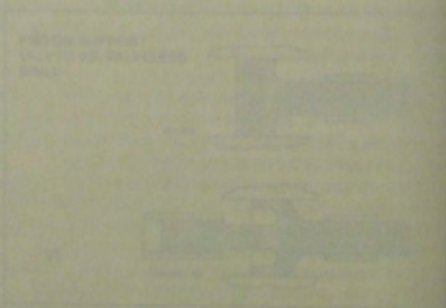
Illustration [illegible] compares penetration rates of valved and valveless drifters under the same conditions. The valveless drifter uses approximately [illegible] less air for the same penetration rate. Therefore, the compressor plant doesn't have to produce as much air. It can conserve fuel, and in addition, reduce wear on that unit as well. The cost of fuel makes this an increasingly important advantage.

Low Noise

Further advantages resulting from the use of expansion during piston travel are that there is less noise, and less tendency to "freeze" when the

drifter is run as the drill steel is withdrawn from the hole. The freezing phenomenon occurs when [illegible] lubricating oil entrained in the compressed air [illegible] drifters due to high pressures developed in the chamber of the drifter. Because of the [illegible] piston support in valveless drifters, [illegible] less oil [illegible] can be used. Less [illegible] produces less oil fog in the exhaust, a consideration for operator comfort and health.

From the viewpoint of maintenance and operating costs, it is apparent that it will pay to replace valve-operated drifters with valveless designs rather than rebuild the former.



Ingersoll-Rand Co.
Rock Drill Division
Phillipsburg, N.J. 08865

INGERSOLL-RAND
DRILLING EQUIPMENT

[illegible]

SECTION 3 : PORTABLE AIR COMPRESSOR SPECIFICATION

INGERSOLL-RAND P375SD

The P375SD is a single stage, oil flooded, rotary screw air compressor. The air compressor is driven by the diesel engine through a flexible coupling and rotor optimizing gears for part load fuel economy.

It is capable of delivering 375 cfm (10.5 m3/min) of free air at 102 psig (7 bar) pressure, at full load rpm. (Maximum 115 psig/7.9 bar). Rated pressure and output is measured AFTER oil separation.

The diesel engine is an in-line air cooled, Deutz, Model F6L912, delivering 112 hp at a rated speed of rpm; no load speed is 1000 rpm. It is equipped with 24 volt starting system.

Built into the unit are the following safety features:-

1. Automatic engine shutdown in the event of:

   (A) High air discharge temperature

   (B) Low engine oil pressure

   (C) High engine coolant temperature

   (D) Low engine coolant level

2. Automatic blowdown valve.

3. Safety valve.

4. Minimum pressure valve.

5. Air filter restriction indicators.

The complete assembly is mounted on rubber mounts on a welded steel frame. The unitized chassis is supported on torsion bar suspension on a single axle; fitted with rubber tyres. Parking brakes and lifting bail is standard. The canopy surrounding the package is sheet steel with lockable side doors for complete accessability.

Enclosed are leaflets fully describing the P375SD air compressor.

PERFORMANCE DATA

FUEL CONSUMPTION

P375SD

Engine Manufacturing	:	Deutz
Model	:	F6L912
Available BHP	:	112
RPM	:	2500
Rated Operating Pressure	:	100 psig

% RATED CAPACITY

50%	ACFM	:	187
	Cub. ft. / lb Fuel	:	507
	Litres/hour		
75%	ACFM	:	281
	Cub. ft. / lb Fuel	:	596
	Litres/hour	:	15.2
100%	ACFM	:	375
	Cub. ft. / lb Fuel	:	608
	Litres/hour	:	20

Introduction

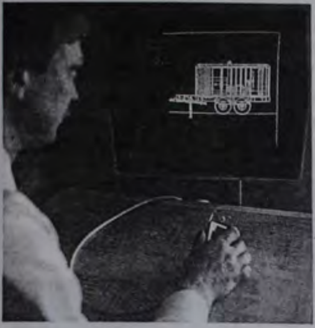
In 1902 Ingersoll-Rand introduced the world's first truly Portable Air Compressor, and has pioneered every major advance in the field since then. We introduced the two-stage air-cooled unit, followed it with the first sliding-vane rotary Portable, and then with the first screw-type Portable. Today we are acknowledged leaders in Portable Compressor technology.

Wherever in the world compressed air is used — on construction sites, in quarries or open cast mines, for road maintenance or water well drilling — the chances are an Ingersoll-Rand compressor will be at work, providing efficient, cost effective performance.

Ingersoll-Rand is a world-wide organisation with a manufacturing, service and distribution network covering virtually every corner of the globe. We maintain our leadership in the Portable Compressor industry because we employ precision manufacturing methods and the most exacting quality control standards.

This brochure is designed to give you an insight into the unmatched development, manufacturing, quality control and back-up service facilities we provide with every Premium Portable, from the smallest 65 cfm (30 lt/sec) unit to the largest, which is capable of delivering 5000 cfm (2350 lt/sec) of air.

Research and Development



Our track record in Portable Air Compressor technology from the beginning of this century illustrates the importance Ingersoll-Rand places on Research and Development. The work goes on today to help us ensure that we can supply the right machine for any and all customer requirements.

As well as producing many product 'firsts', the continuous research and engineering development programmes help to create new materials and new manufacturing methods and skills, which can be applied to the design of new machines and can also contribute to the improvement of existing products.

Every new idea is thoroughly tested by our compressor technology professionals and discussed with end-users. Our Research and Development test cells provide the environment for theoretical ideas to be put to practical examination. Only when they have passed all the tests will they be incorporated into new product designs.

Creative engineering has kept Ingersoll-Rand Portables ahead of the field by bringing new ideas into action to produce premium products which combine the highest levels of efficiency with outstanding performance and economy of operation.

Quality Control and Testing

At every stage of manufacture Ingersoll-Rand Portable Compressors are subjected to a rigourous regime of quality control testing, in order to ensure that our standards are met, and that the customer receives the premier portable he expects.

For example, all the critical dimensions on rotor housings are examined on computer-assisted inspection machines. Permanent records are produced of every inspection.

Once total assembly is complete — when the air end, engine, chassis, auxilliaries and controls have been brought together — each unit is acceptance tested.

Every new Ingersoll-Rand Portable undergoes many hours of operation to provide the break-in, regulation and performance test data required.

Only those that pass this final examination get our coveted seal of approval — an Ingersoll-Rand nameplate.

Whisperised® versions of the compressors are tested on the most advanced sound-testing facilities in the industry, which enable our engineers to monitor and analyse the noise levels around a compressor with a high degree of accuracy and make sure they meet noise-control regulations where necessary.

Precision Manufacturing

Creative engineering counts for nothing if it is not matched with the highest manufacturing standards.

Ingersoll-Rand has the ability to match its engineering standards with manufacturing excellence. Wherever in the world Ingersoll-Rand Portable Compressors are produced only the most advanced metal-working equipment is used, so the same level of accuracy is achieved globally.

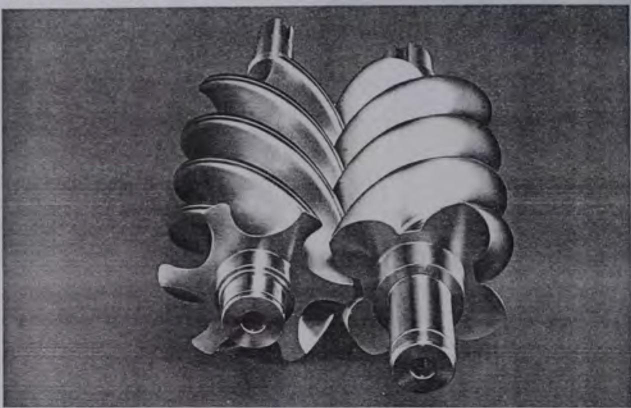
Rotor housings are precision-bored with great accuracy. Close rotor clearance is an important factor in improving efficiency — rotors must turn freely within the housings, but the clearances must be close enough to minimise air slippage. The right machine tools, operated by well-trained staff, provide the assurance that Ingersoll-Rand rotor housings are manufactured to the highest standards possible.

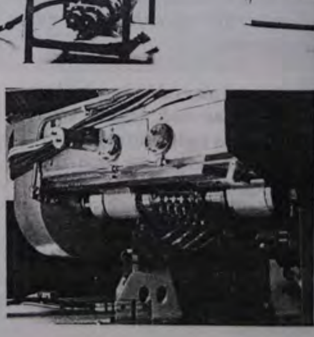
The manufacture of the rotors is the most critical operation of all. It involves the precision-machining of extremely complex rotor shapes from cylindrical blanks of high-grade solid steel. Highly specialised contour milling machines — a part of the Ingersoll-Rand worldwide investment in producing only the finest compressors — are used to generate the rotors from bar stock.

All rotors for compressors of 175 cfm capacity and over are precision ground to a glistening mirror-like finish in order to approach the theoretical ideal of a rotor profile and also to reduce fluid friction on all rotor surfaces — another important factor in improving efficiency.

Rotors for the smaller 100 and 175 cfm compressors are produced in a two-stage operation called Rotor Hobbing. In these small sizes where the compressors run intermittently and engine horsepower is small, hobbed rotors provide the level of efficiency required.

The mating of rotors is the final, critical step. Male and female rotors are precision matched and then each pair is inspected for back-lash and interlobe clearance. The attention paid to this critical operation produces the nearest to screw compressor perfection attainable today.





Parts and Service Worldwide

Ingersoll-Rand compressors are built to stay the course. They will provide long hours of trouble-free operation — but at some stage they will need servicing.

With our own automated 24 hours-a-day parts service, and a network of our own autonomous Companies and Distributors located in every part of the world, we are geared to provide our customers with the fast, efficient back-up required to keep the machines operational.

Distributors and the autonomous Companies hold inventories of spare parts. If, by chance, the part you require is not in stock a call to one of our strategically-located computer-controlled parts stores will have the missing item on its way in a hurry.

Parts availability and worldwide back-up service are additional reasons for selecting an Ingersoll-Rand Portable Compressor.

Ingersoll-Rand Genuine Parts

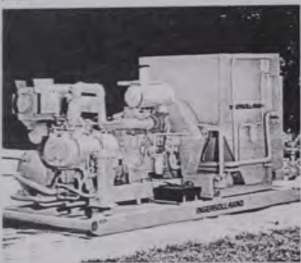
To keep your Portable Compressor at peak performance, you should insist on only genuine Ingersoll-Rand replacement parts.

Substitutes may cost less at the time of purchase, but their useful life will be shorter, and the risks of failure and consequential damage to your Portable Compressor are much higher.

Don't take the risk — insist on Ingersoll-Rand's precision-manufactured and tested spare parts.

Products

P100 W.



XHP 900 skid-mounted oilfield unit.

Illustrated here are four examples from the comprehensive range of Ingersoll-Rand Portable Compressors:

P250 W.

XHP 700

INGERSOLL-RAND

P140/P175/P250/P375 WHISPERISED®

A range of precision engineered portable compressors, designed for low maintenance, maximum efficiency, economic operation and maximum operational life.

Quiet Operation
All models meet or surpass CAGI-PNEUROP noise emission standards, and can therefore be used in areas where strict noise emission standards are in force.

Heavy Duty Engines
All models incorporate industrial type diesel engines which, dependent on unit selected, are air or water cooled and deliver from 51 bhp (38 kw) to 112 bhp (83.5 kw) at a speed of 2,500 r.p.m. All models provide outstanding fuel economy.

Air-Ends
Compressor rotors are precision-machined to the ideal design profile. Other components are precision die-cast. The result: greater efficiency and lower fuel consumption.
Engines and air-end assemblies are mounted on heavy gauge all-steel chassis by means of special rubber mounts, thereby isolating vibration.

Air Regulation
The Stepless system, from idle to full engine speed, allows for a continuous, smooth flow of compressed air output in response to air demand.

Air Oil Separation
Less than 10 p.p.m. due to a two-stage separation system.

Unique Cooling
All models are designed to operate with doors closed. The unique cooling system allows the units to operate in ambient conditions, depending on the machine model, of up to 125° (52°C).

Two Stage Dry Type Air Filters
The engine and air-end are protected by separate air intake filters equipped with filter element restriction indicators.

Running Gear
Two types of torsion bar suspended running gear are available. The first incorporates a low-bar that can be adjusted to suit the height of the towing vehicle and meets European specifications. The other is a rigid towing bar running gear which meets EEC specifications. Wide wheel base, high ground clearance and a low centre of gravity make all models very stable on even the roughest ground. The run brake system provides for excellent braking characterist hand parking brake which allows for safe parking is a sta fitting.

Ease of Access
The large lockable doors, the lifting of which is aided by gas struts, open wide allowing full accessibility to all maintenance areas and the large tool storage space.

Controls and Instrumentation
The maintenance-free control system provides for automatic shutdown by high discharge air temperatures, low engine oil pressure, or high engine temperature. Signal lights show the cause of protective shutdown. Instruments include discharge air pressure gauge and engine hour meter. Starting and operating controls are located in a lockable enclosure for protection against vandalism.

Une gamme de compresseurs mobiles fabriquée avec précision et conçue pour un entretien réduit, un rendement maximum, un fonctionnement économique et une durée de vie opérationnelle maximum.

Fonctionnement silencieux
Tous les modèles satisfont ou dépassent les normes d'émission de bruit CAGI-PNEUROP, et peuvent donc être utilisés dans les endroits où des normes strictes d'émission de bruit sont en vigueur.

Moteurs grande puissance
Tous les modèles sont équipés de moteurs diesel industriels qui, selon la machine choisie, sont refroidis par air ou par eau et ont une puissance de 38 kW (51 ch) à 83,5 kW (112 ch) à 2500 t/mn. Tous les modèles offrent une excellente économie de carburant.

Compresseurs
Les rotors du compresseur sont usinés avec précision selon le profil idéal. Les autres composants sont réalisés par moulage mécanique de précision. Le résultat: un rendement plus élevé et une consommation de carburant plus faible.
Les moteurs et les compresseurs sont montés sur des châssis en tôle d'acier de forte épaisseur par l'intermédiaire de plots spéciaux en caoutchouc, isolant ainsi des vibrations.

Régulation d'air
Le système progressif, du ralenti à la pleine vitesse, pemet un débit d'air comprimé uniforme répondant totalement à la demande d'air.

Séparation air-huile
Inférieure à 10 p.p.m. grâce au système de séparation à deux étages.

Refroidissement unique
Tous les modèles sont conçus pour pouvoir fonctionner avec les portes fermées. Le système de refroidissement unique permet aux unités de fonctionner dans des conditions ambiantes allant jusqu'à 52°C, en fonction du modèle de machine.

Filtres à air secs bi-étages
Le moteur et l'ensemble compresseur sont protégés par des filtres d'admission séparés, équipés d'indicateurs de colmatage de l'élément filtrant.

Châssis
Deux types de châssis à suspension par barres de torsion sont disponibles. Le premier comporte un timon réglable en fonction de la hauteur du véhicule de remorquage et est conforme aux spécifications européennes. Le second est un châssis à timon rigide conforme aux spécifications de la C.E.E. Des roues largement espacées, une garde au sol importante et un centre de gravité bas rendent tous les modèles très stables, même sur les terrains les plus accidentés. Le système de frein d'emballement offre d'excellentes caractéristiques de freinage. Un frein de stationnement est fourni en équipement standard.

Facilité d'accès
Les grandes portes verrouillables, dont l'ouverture est assisté par des équilibreurs à gaz, s'ouvrent sur une grande largeur et donnent une accessibilité totale à tous les organes à entretenir et au grand espace de rangement des outils.

Commandes et instrumentation
Le système de commande sans entretien assure un arrêt automatique en cas de température élevée d'air de service, de faible pression d'huile ou de haute température du moteur. Des lampes indicatrices donnent la cause de l'arrêt. Les instruments comprennent un manomètre d'air de service et un compteur horaire du moteur. Les commandes de mise en marche et d'exploitation sont regroupées dans un boîtier anti-vaudalisme.

Baureihe fahrbarer Schraubenkompressoren mit geringem Wartungsaufwand, langer Lebensdauer und wirtschaftlichem Betrieb.

Geräuschpegel
Alle Modelle unterschreiten die AVV-Normen. Sie können eingesetzt werden, wo Geräusche auf ein Mindestmaß herabgesetzt werden müssen.

Hochleistungsmotoren
Alle Modelle besitzen Dieselmotoren, die je nach Modell entweder luft- oder wassergekühlt sind. Die Leistung dieser Motoren liegt zwischen 38 und 83,5 kW bei 2500 U/min. Sie zeichnen sich alle durch hohe Wirtschaftlichkeit aus.

Kompressor
Das Schraubenpaar wird mit engsten Toleranzen gefertigt, um das ideale Läuferprofil zu erreichen. Andere Komponenten sind präzisionsgegossen. Das Resultat: größere Effizienz und noch sparsamerer Kraftstoffverbrauch. Motor- und Kompressor werden mit speziellen Gummidämpfern in einem Chassis aus hochwertigem Stahl montiert, um eine größere Laufruhe zu erzielen.

Liefermengenregelung
Die stufenlose Liefermengenregelung von Leerlauf bis Vollast sorgt für eine gleichmäßigen, kontinuierliche Liefermenge je nach Luftbedarf.

Luft-Öl-Abscheidung
Aufgrund eines äußerst wirksamen Zweistufen -Abscheid systems beträgt der Rest-Ölgehalt der Druckluft weniger als 10 p.p.m.

Kühlung
Alle Modelle werden mit geschlossenen Türen und Klappen betrieben. Das werksame Kühlsystem ermöglicht es, die Kompressoren, selbst bei Umgebungstemperaturen bis zu 52°C, einsuzetzen.

Zwei-Stufen-Trockeneinlaßluftfilter
Motor und Kompressor werden durch separate Lufteinlaßfilter geschützt, Filterkontrolle durch verschmutzungsanzeiger.

Fahrgestell: Straßenlage
Es sind zwei Varianten mit Drehstabfederung lieferbar. Ein Fahrgestell hat eine höhenverstellbare Zugvorrichtung, die den Spezifikationen europäischer Länder entspricht. Die andere Variante besitzt eine in der Höhe nichtverstellbare Zugvorrichtung, die EG-Bestimmungen gerecht wird. Die breite Spurweite, der hohe Bodenabstand und der niedrige Schwerpunkt sorgen für eine sehr sichere Straßenlage des Kompressors beim Schleppen sowohl auf der Straße als auch im Gelände. Die Auflauf- und Feststellbremse wirken sehr zuverlässig.

Leichte Zugänglichkeit
Die großen verschließbaren Klappen, die sich leicht d[...] Gasdruckfedern anheben lassen, machen alle Wartungsber[...] leicht zugänglich. Außerdem ist eine großzügige Werkzeuga[...] vorhanden.

Regler und Instrumente
Das Sicherheitssystem sorgt für eine automatische Stillegung des Kompressors bei zu hohen Lufttemperaturen, zu niedrigem Öldruck, zu hohen Motortemperaturen. Signalleuchten weisen auf die Ursache einer vorbeugenden Ausschaltung hin. Zu den Instrumenten gehören ein Betriebsdruck-Manometer und ein Betriebsstundenzähler. Start- und Betriebsregler können durch eine verschließbare Klappe vor unbefugtem Zugriff gesichert werden.

Gamma di motocompressori trasportàbili, progettati per ridurre al minimo la manutenzione, con la massima efficienza ed economia di servizio.

Rumorosita'
Tutti i modelli sono disponibili sia in versione standard che silenziata. In questo secondo caso sono conformi alle norme europee vigenti e pertanto possono venire impiegati in zone con rigorosi regolamenti anti-rumore.

Motori Diesel
Tutti i motocompressori sono equipaggiati con motori diesel che, a secondo del modello, sono raffreddati ad aria o ad acqua ed erogano una potenza variabile da 51 HP (38 kW) a 83.5 HP (83.5 kW).
Particolare attenzione e stata posta nella riduzione dei consumi.

Compressore a Vite
I rotori sono stati lavorati con finitura di altissima precisione cosi come tutti gli altri componenti. Come risultato si sono ottenute una grande efficienza e ridotti consumi di carburante.
Motore e compressore sono montati su di un robusto telaio in acciaio per mezzo di adeguati supporti in gomma che isolano dalle vibrazioni.

Regolazione della portata
La regolazione di tipo continuo e progressivo, dal regime di minimo al massimo numero di giri del motore, consente di soddisfare la richiesta d'aria con una erogazione uniforme.

Separazione aria olio
Meno di 10 ppm grazie di olio al sistema di separazione a due stadi.

Raffreddamento
Tutti i modelli sono stati progettati per operare a portelloni chiusi. Il sistema di raffreddamento consente di operare, a seconda del modelle, fino a una temperatura ambiente di 52°

Filtri aria a due stadi di tipo a secco
Motore e compressore sono dotati di filtri di aspirazione completi di indicatori di intasamento dell'elemento filtrante.

Timone
Sono disponibili due differenti timone di traino.
Un tipo incorpora una barra regolabile in funzione dell'altezza del veicolo trainante e risponde alle vigenti norme europee. Un secondo modello è equipaggiato di barra fissa. L'ampia carreggiata, l'altezza da terra ed il basso baricentro garantiscono la massima stabilità anche sui tereni più accidentati. L'impianto frenante di tipo a repulsione è sinonimo di eccellenti caratteristische di frenatura un freno meccanico di stazionamento manuale equipaggia di serie tutti i modelli.

Accessibilita'
Due grandi sportelloni con seratura a chiave il ciu sollevamento è facilitato da pistoncini a gas, permettono il massimo accesso a tutti i componenti che possono richiedere un intervento manutentivo e ad un capiente vano per lo stivaggio di attrezzi.

Pannello strumenti e comandi
Un circuito che non richiede manutenzione, comanda l'arresto del motocompressore in seguito ad alta temperatura aria allo scarico, bassa pressione olio del motore o alta temperatura motore.
Apposite spie segnalano la causa dell'arresto.
Gli strumenti comprendono unmanometro aria di scarico ed un contaore motore. I pulsanti per l'avviamento sono posizionati in un vano dotato di sportello a chiave contro atti vandalici.

Una gama de compresores portátiles de precisión, concebidos para proporcionar una duración operativa máxima con economía, máxima eficiencia y reducidas necesidades de mantenimiento.

Funcionamiento silencioso
Todos los modelos cumplen o exceden las normas de emisión de ruido CAGI-PNEUROP y pueden, por lo tanto, utilizarse en zonas donde se aplican normas estrictas de emisión de ruido.

Motores para trabajos pesados
Todos los modelos incorporan los motores diesel tipo industrial; de acuerdo con la unidad seleccionada, pueden ir enfriados por agua o aire y entregan de 38kW a 83,5kW a una velocidad de 2.500 r.p.m. Todos los modelos son excepcionalmente económicos en el consumo de combustible.

Compresores
Los rotores de los compresores se hacen mecanozados con precisión de acuerdo con el perfil de diseño ideal. Otros componentes se hacen troquelados a precisión. El resultado es una mayor eficiencia y más bajo consumo de combustible.
Los conjuntos de motor y compresor van montados sobre un chasis de acero grueso por medio de monturas de goma especial, aislándolos así de la vibración.

Regulación neumática
El sistema progresivo, desde la marcha lenta a la velocidad máxima del motor, permite una producción continua de flujo constante de aire comprimido en respuesta a las necesidades de aire.

Separación de aire y aceite
Menos de 10ppm debido al sistema de separación bietápico.

Enfriamiento excepcional
Todos los modelos se han diseñado para que functionen con las puertas cerradas. El excepcional sistema de enfriamiento permite funcionar a las unidades en condiciones ambientales que, de acuerdo con el modelo de máquina, pueden alcanzar 52°C.

Filtros neumáticos bietápicos de tipo seco
El motor y el compresor están protegidos por filtros individuales de admisión de aire, equipados con indicadores de restricción del elemento de filtro.

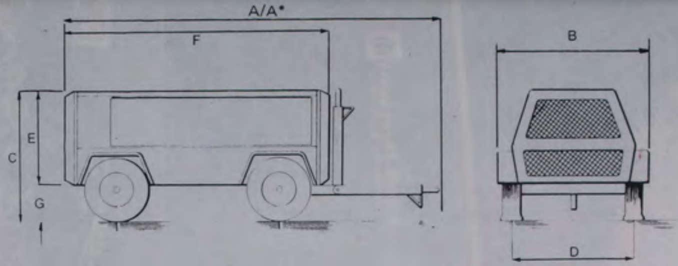
Sistema de rodadura
Se dispone de dos tipos de sistemas de rodadura con suspensión por ballestas. El primero incorpora una barra de remolque que se pueda ajustar para adaptarla a la altura del vehículo remolcador y cumple las especificaciones europeas. El otro es un sistema de rodadura con barra de remolque rígida que cumple las especificaciones de la CEE. La amplia base entre ruedas, elevada separación del suelo y bajo centro de gravedad, hacen que todos los modelos sean muy estables incluso en los terrenos más escabrosos. El sistema de freno de sobrevelocidad proporciona unas características excelentes de frenaja. El freno manual de aparcamiento que permite un aparcamiento seguro es un dispositivo normal.

Facilidad de acceso
Las grandes puertas con cerraduras, cuyo levantamiento se facilita por medio de cilindros de gas, se abren ampliamente permitiendo una accesibilidad completa a todas las zonas de mantenimiento y el amplio espacio de almacenamiento de herramientas.

Controles e instrumentos
El sistema de control exento de mantenimiento proporciona ur terrupción automática del funcionamiento debido a elevadas peraturas del aire de descarga, baja presión del aceite del motu u elevada temperatura del motor. Las luces indicadoras señalan la causa de la interrupción protectora del functionamiento. Los instrumentos incluyen un manómetro de aire de descarga y un contador de horas de funcionamiento del motor. Los controles de puesta en marcha y funcionamiento se hallan dentro de un compartimiento con candado para protegerlos contra el vandalismo.

Form No. LN8104
Printed in UK

P375 SD
VHP 260



MEASUREMENTS AND WEIGHTS
DIMENSIONS ET POIDS
MASSE UND GEWICHTE
DIMENSIONI E PESI
DIMENSIONES Y PESOS

Measurements and Weights		Dimensions et poids		Masse und Gewichte		Dimensioni e Pesi		Dimensiones y pesos		P375SD	VHP260
Overall Length Fixed Towbar	A m	Longueur hors tout Timon fixe	A m	Gesamtlaenge Feststehende Zugvorrichtung	A m	Lunghezza totale con barra di traino fissa	A m	Largo Total Lanza fija	A m	4.23	4.23
Overall Length Max. Adjustable Towbar	A* m	Longueur hors tout Timon reglable	A* m	Gesamtlaenge verstellbare Zugvorrichtung	A* m	Lunghezza totale con barra di traino regolabile	A* m	Largo Total max. Lanza graduable	A* m	3.36	3.36
Overall Width	B m	Largeur hors tout	B m	Gesamtbreite	B m	Larghezza Totale	B m	Ancho Total	B m	1.56	1.56
Overall Height	C m	Hauteur hors tout	C m	Gesamthoehe	C m	Altezza Totale	C m	Altura Total	C m	1.70	1.73
Track Width	D m	Voie	D m	Spurweite	D m	Passo	D m	Ancho de via	D m	1.33	1.33
Canopy Height	E m	Hauteur capot	E m	Hoehe Geshaeuse	E m	Altezza cella carrozzeria	E m	Altura de la carena	E m	1.07	1.07
Canopy Length	F m	Longeur capot	F m	Laenge Gehaeuse	F m	Lunghezza della carrozzeria	F m	Largo de la carena	F m	2.88	2.88
Ground Clearance	G m	Garde	G m	Bodenfreiheit	G m	Altezza minima da terra	G m	Luz libre	G m	0.23	0.23
Gross Weight	kg	Poids brut	kg	Bruttogewicht	kg	Peso Lordo	kg	Peso bruto	kg	1920	2025
Tyre Size		Dimensions Pneus		Reifengroesse		Dimensione dei Pneumatici		Tamaño neumáticos		670 x 13 6PR	

Ingersoll-Rand reserve the right to change specifications without notice. Errors and omissions excepted.
LN 8117 4/85

INGERSOLL-RAND

P375 SD
VHP 260

COMPRESSOR AND ENGINE
COMPRESSEUR ET MOTEUR
KOMPRESSOR UND MOTOR
COMPRESSORE A MOTORE
COMPRESOR Y MOTOR

Rated Pressure	Gamme pression	Nenndruck	Pressione di esercizio	Presión normal	102(7.0) 700	200(13.6) 1360
Model	Modèle	Modell	Modello	Modelo	P375SD	VHP 260
Compressor and Performance	**Compresseur et performance**	**Kompressor und Leistung**	**Caratteristiche tecniche**	**Compresor y Actuacion**		
Compressor Type	Type compresseur	Kompressor Typ	Tipo di Compressore	Tipo de compresor	Single Stage Screw Avis Mono étage Einstufige Shraube	Monostadio a Veti Tornillo una Eta
Free Air Delivery cfm, (m^{3}min), [l/s]	Débit effectif en air libre cfm, (m^3/min), [l/s]	Liefermenge cfm, (m^{3}min), [l/s]	Portata d'Aria Effectiva cfm, (m^{3}min), [l/s]	Caudal de aire libre cfm, (m^3 min), [l/s]	375(10.5) [177]	260(7.38) [123]
Rated Operating Pressure psig, (bar), [KPa]	Pression de service psig, (bar), [KPa]	Betriebsdruk psig, (bar), [KPa]	Pressione Normale d'esercizio psig, (bar), [KPa]	Presión de trabajo psig, (bar), [KPa]	102(7.0) [700]	200(13.6) [1360]
Maximum Pressure psig, (bar), [KPa]	Pression maximum psig, (bar), [KPa]	Hoechstdruck psig, (bar), [KPa]	Pressione Massima psig, (bar), [KPa]	Presión máxima psig, (bar), [KPa]	114(7.9) [790]	210(14.4) [1440]
Air Outlets	Sorties d'air	Luftablasshaehne	Prese d'aria	Salidas de aire	3 x R ¾"	1 x R 1¼"
Operating Ambient Temp. Range @ Sea Level	Temp. ambiante d'utilisation au niveau de la mer	Umgebungstemperatur Bereich ueber Meeresspiegel	Temp. d'Ambiente per Funzione- mento Norm. al Livello del Mare	Temp. ambiente para operación al nivel del mar	−23°C to 52°C	−23°C to 46°C
Engine Data	**Détails moteur**	**Motor-Daten**	**Caratteristiche del Motore**	**Datos del Motor**		
Type	Type	Type	Tipo	Tipo	Deutz	Deutz
Model	Modèle	Modell	Modello	Modelo	F6L912	BF6L913
Number of Cylinders	Nombre de cylindres	Zylinderanzahl	Numero di Cilindri	Número de cilindros	6	6
Rated Speed R.P.M.	Vitesse t/mm	Nenndrehzahl U/min	Velocità a pieno carico	Velocidad normal R.P.M.	2500	2400
BHP/KW Available at Rated Speed	Ch/KW regime nominal (DIN B 6270)	Leistung bei Nenndrehzahl U/min	Potenza (BHP/KW) Disponibile a pieno carico	BHP/KW disponible a velocidad normal	112/83	143/107
No Load (Idle) Speed R.P.M.	Vitesse au ralenti t/mn	Leerlaufdrehzahl U/min	Giri a Regime Minimo (Giri/min.)	Velocidad sin carga (en vacio) RPM	1400	1400
Fuel Tank Capacity Imp Gal/(Litre)	Capacité réservoir combustible Gallon impérial/litre	Kraftstofftankinhalt Gallonen/Liter	Capacitá serbatio carburante Gallon: Imp/(Litri)	Capacidad tanque combustible Gal. Imp./(Litro)	36(163)	36(163)

INGERSOLL-RAND

PRESSURE IS PRODUCTIVITY

Higher pressure air provides significant boost in rock drill rates.

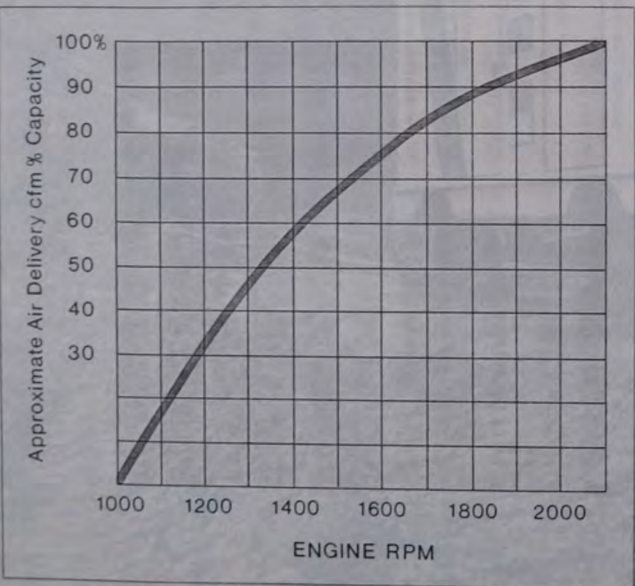
Problem: You have been producing rock for years with the same drill and compressor, which have given few problems and have been very reliable. You might have forgotten them except for the weekly paychecks to the driller and the monthly charges from your powder company.

You have a problem and probably don't realize it.

How would you like to reduce overtime paid to the driller, reduce the number of days of drilling, possibly decrease the cost of bits and steel per foot of hole drilled, and generally increase the overall productivity of your quarry?

Solution: The answer is "pressure." First, you must establish what production you have now and under what conditions. Observe on your drill and compressor while the driller is putting in a typical hole:

A. Engine rpm while drilling.
B. Pressure at the compressor.
C. Time required for one hole: i.e., from the time the bit first touches rock to the time the bit is no longer going down. Add to this the times required to remove the bit from the hole and for the driller to set up on the next hole.



The relationship of engine rpm to the air delivered by the compressor.

With these three items of data, the following parameters can be established.

1. Engine rpm is a direct relationship to the compressed air delivered by the compressor. The graph may be used to determine the approximate percent of full-load cfm output for rotary (screw or vane) units. Most applications are probably 100 percent. However, if the engine is running at less than full-load rpm, then the compressor is not putting out its rated capacity. (Note that the compressor will only deliver the air [cfm] used by the drill plus air leakage, etc.) Determine the approximate cfm output. This is the cfm consumed by the air system or drill.
2. Pressure at the compressor. Sounds easy, but look out for broken gauges. It would not hurt to check the accuracy of the gauge because pressure is critical to your productivity. Also, determine *where* pressure is measured by the gauge on your compressor.

Take the pressure reading you get and deduct *5 psi* if pressure is measured prior to the separator element on rotary units. This can easily be determined because, if pressure gauge connection is on the large separator tank, it measures before oil separation. If the connection is on the discharge line that goes directly to the air hose, it is after oil separation and do not deduct 5 psi.

Deduct *15 psi* for an approximation of the pressure loss through the rock drill—lubrication, hoses, valves, etc. prior to the hammer or drifter. (Note: If you have a needle gauge and can get

...reading at the inlet (gooseneck) of the drifter, you can more accurately determine this pressure loss.) The final pressure number you have is an approximation of the air pressure on the hammer).

Take the time required to drill one hole (as described) and divide the depth of the hole (feet) by this time (minutes). This number represents actual penetration for every minute of operation using the volume (Step 1) and pressure (Step 2) available. Then take the total time (bit penetration plus steel additions plus bit removal from the hole and set up on the next hole) and divide it into the depth of the hole. This number represents how many feet can be drilled (overall penetration) considering all phases of the driller's operation.

An example may clarify this method. A quarry had a 600-cfm compressor drilling a 40-foot-deep hole with ... steels. The compressor engine is running at 2100 rpm. The compressor pressure gauge reads 100 psi ... gauge connection is to the large ... tank. Time required to drill ... hole: 40 minutes, including 1 minute ... steel change. This is ... minutes of actual drilling ... Also, the driller takes 5 minutes ... out of the hole and 2 minutes to reposition the drill for the next hole.

1. Assume the compressor is putting out 600 cfm.
2. Estimate the pressure at the hammer:

Compressor gauge pressure:	100 psig
Deduct pressure drop:	
Separator element	−5 psig
Hoses and fittings	−15
Pressure at the hammer =	80 psig

3. Estimate actual drill rate.
   Feet drilled: 40 feet
   Time: 37 minutes

   Therefore, actual drill rate $\frac{40}{37}$

   = 1.08 feet/min or 65 feet/hour

Now, you want to estimate your actual drill rate with higher pressure air. Consider a portable compressor that would hold 125 psig (measured after the separator) at the compressor and estimate the actual drill rate.

1. Compressor gauge pressure (measured after the separator element):

Compressor gauge pressure (measured after the separator element):	125 psig
Deduct pressure drop through hoses and fittings	−15
Pressure at the hammer =	110 psig

2. Estimate actual drill rate:
   Percent increase in penetration at 110 psig = 55 percent

(Fro...
Increa...
55 ...
65 ...
101...
or 1...

3. Time r... hole...

40 fe...
1.68 feet...
= ...

Therefore ... would occur ... drilled. Tab... would have ...

With the ... (51 and 71 ... the advanta... two ways: ... *creased ope...*

Increase... pattern and ... per foot of ... creased roc... in your mar...

Pattern 7 × ...

(63 ft^3 per f... × 20* fe... /27 ft^3/y...

* Difference betwe...

This is a... rock for ev...

... If you have a drifter with 80 psig ... the rock at a rate of 200 feet/hour ... inches/minute and you want to know ... approximate actual penetration to expect ... pressure is raised to 110 psig. Go ... curve at 110 psig and read plus 55 percent increase in penetration. Multiply 200 ... times 1.55, or 310 feet per hour. ... be adjusted for steel changes, drill setups, etc., to get the overall penetration. (For drifters with pressures different than 80 psig). If you have a drifter with ... penetrating the rock at a rate of 200 ... hour, 3.3 inches/minute and you want ... the approximate actual penetration to ... the drifter pressure is raised to 110 ... Go the curve at 90 psig and read plus ... Go to the curve and read plus 55 ... at 110 psig. Multiply 200 feet/hour ... and divide by 1.17. 200 × ... = 265 feet/hour. Adjust this ... for steel changes, drill setups, etc., to ... overall penetration.

drill 10 hours a day for 5 days a week, you will get 5250 tons more with 125-psig air than with 100-psig air. If the rock is sold for \$2 per ton, you will increase your revenues by \$10,500 a week (\$42,000 per month or \$504,000 per year and so on.)

Decrease operating cost. Assume that you only want to produce a certain tonnage of rock per year—4,000,000 tons.

Actual: 4,000,000 tons.

$(4{,}000{,}000 \text{ tons} \times 27 \text{ ft}^3/\text{yd}^3)$
$/(2.25 \text{ tons/yd}^3 \times 51 \text{ feet/hour} \times 63 \text{ ft}^3 \text{ per foot of hole drilled})$
$= 1494$ hours drilling

Projected: 4,000,000 tons.

$$\frac{4{,}000{,}000 \times 27}{2.25 \times 71 \times 63} = 1073 \text{ hours of drilling}$$

Difference: $1494 - 1073 = 421$ hours

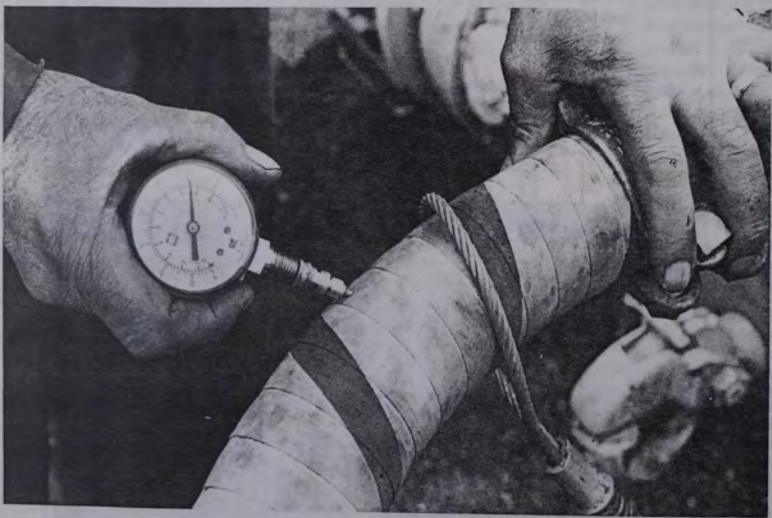
Time-saving using 125 psig is 421 hours of drilling. If 1 hour of the operator is valued at \$20/hour, the savings per year would be *\$8420* or for 10 years, *\$84,200*. The money involved is considerable, especially in the long term. You should get the numbers for your rock-drilling operation, crank out the results, and you will believe that "pressure is productivity." □

—***William L. Bishop***

TABLE 1. EFFECT OF HIGHER PRESSURE AIR ON PRODUCTIVITY

	Actual at 100 psig	Projected at 125 psig
Drill rate	65 feet/hour Or 1.08 feet/minute	101 feet/hour 1.68 feet/minute
Time to drill 40-foot hole	37 minutes	24 minutes
Add time for steel change	3 minutes	3 minutes
Add time for steel removal from hole	5 minutes	5 minutes
Add time to reposition drill	2 minutes	2 minutes
Total time to drill hole	47 minutes	34 minutes
Overall drill rate	$\frac{40 \text{ feet}}{47 \text{ minutes}} = 0.85$ feet/minute	$\frac{40 \text{ feet}}{34 \text{ minutes}} = 1.18$ feet/minute
Or	51 feet/hour	71 feet/hour 20 feet/hour increase overall

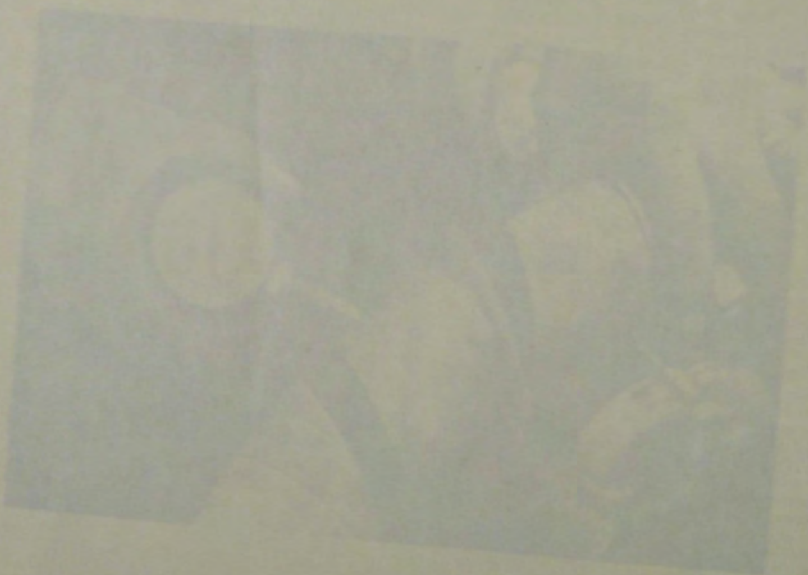
WILLIAM L. BISHOP is manager of sales support, Portable Compressor Division, Ingersoll-Rand Company, Mocksville, North Carolina.



Ingersoll-Rand Company
Portable Compressor Division
Mocksville, North Carolina 27028

Form 2047 Printed in U.S.A.

INGERSOLL-RAN
CONSTRUCTION EQUIPMEN



SECTION 4 : UNDERWATER OPERATIONS OF INGERSOLL-RAND CRAWLAIR DRILL RIGS

The versatility of the Ingersoll-Rand Crawlair drill rigs is unsurpassed. One of the many uses of the rigs has been for underwater blasthole work.

The particular project in the Tokelau Islands does not call for completely submerged drill rig operation. However, it is recommended that the modifications mentioned be carried out to ensure maximum drilling efficiency and trouble free operation.

Attached are reproductions of several articles describing the ability of our rigs on underwater drilling. The lesson learned from these applications has been that drillers should not be deterred from trying the different or unusual when a job, such as the Tokelan Island project, requires a novel approach. As invariably these lead to faster and more efficient project results.

RECOMMENDED CRAWLAIR MODIFICATIONS FOR UNDERWATER OPERATIONS

1) Air supply - pressure to be 125 psig

2) Drifter -

   a) Exhaust to be piped to surface.
   b) Drifter to be cycling at part throttle before submerging. Do not shut off under water.
   c) After underwater operation, the main air hose should be disconnected at the drifter, rock drill oil poured in, and the piston cycled for a brief time to ensure oil coating on all internal surfaces.

3) Remote Manifold - exhaust elbows to be piped to surface

4) Feed Motor - air bleed exhaust elbows to be piped to surface

5) Hydraulic Pump Air Motor - pipe both exhaust elbows to surface

6) Hydraulic Tank - vent cap to be piped to surface

7) Propelling Motors -

   a) Vent caps to be piped to surface.
   b) Exhausts to be piped to surface.

8) Propelling Control Valves - exhaust elbows to be piped to surface

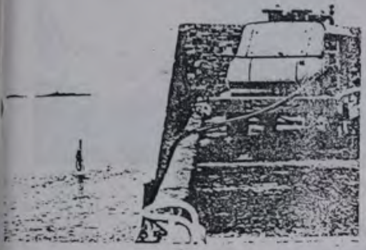
9) Lubricator - nozzles to be adjusted for greater oil flow than normal

In order to avoid running individual holes to the surfaces for each exhaust or vent connection, it is recommended that all these hoses be connected to a manifold with a single hose of at least 3" diameter which is then run to the surface. At the surface, the single hose could be supported by some type of float.

The Crawlair would be submerged for drilling, but then be brought immediately to the surface when not actually drilling. All lubrication fittings should be well greased between drilling shifts.

Land crawler drill plunges into the briney waters of Amlwch Harbor for another underwater drilling shift. The Ingersoll-Rand land drill required only minor initial modifications and a few changes in maintenance procedures to handle this task of subaqueous drilling. Shown in picture at bottom right, partially submerged crawler is steered by diver into operating position. Below, diver-driller goes underwater with his rig.

Portable compressor, an Ingersoll-Rand 600-cfm Gyro-Flo, supplied air for submerged rig. The top of the drill tower can be seen protruding from the water at the left.



LAND DRILL RIG GOES UNDERWATER

An unusual approach to harbor deepening has proved to be fast and efficient

Crawler drills, like most land construction equipment, have rarely been used in marine environments; it may never have occurred to most drillers to take a standard rock drill into water for submerged blasthole work, particularly in corrosive salt water. However, with the year-long success of a land crawler drill working in sea water off the coast of North Wales, a new dimension in equipment versatility has been demonstrated.

Working in the rough shallows of Amlwch Harbor on the Welsh island of Anglesey, a pneumatic crawler rig has drilled the shot holes for blasting more than 12,000 cubic yards of harbor bottom for North Sea oil shipping facilities in its first 5 months. Apart from minor modifications and a few special maintenance steps, no special preparations were necessary, and no major problems were encountered in drilling.

It is difficult and generally inefficient to drill underwater blastholes in waters too shallow and rough for pontoon vessels to negotiate. Hand drills operated by divers can handle enough shot-hole work for blasting 40 to 50 cubic yards per day of harbor bottom, according to Precision Blasting, Ltd., the British contractor on the Anglesey job. However, by minor adaptions to a conventional self-propelled crawler drill—in this case, an Ingersoll-Rand CM150A Crawlair unit—plus certain special maintenance precautions, the firm averaged five times as much drilling as possible manually, to permit blasting 250 cubic yards daily. On the best days, Precision Blasting managed as much as eight times more blasting volume than manual drilling, for 400 cubic yards per day removal of silt and rocky seafloor.

Amlwch Harbor is little more than a cove in Anglesey's windy north coast, only 650 feet wide at its mouth and poking 1200 feet into the cliff-studded shoreline. In the eighteenth century, it was a bustling shipping center for small vessels loading ore from nearby copper mines. More recently, with mines exhausted, the only traffic in the harbor has been fishing smacks and, once in a while, launches boarding pilots for ships inward-bound for Liverpool.

Compressed Air

MARCH 1976

Photo: Warren Williams

Underwater drilling to deepen Wales' Amlwch Harbor involved a special, yet simple, adaptation to a standard land rig, enabling it to effectively bore shot holes in water depths less than 15 feet. A diver sets up the business end of the air-powered rig prior to actual drilling. The novel approach to shallow-water drilling proved better than pontoon vessels or manual methods. See page 6.

DEPARTMENTS

A REVIEW OF THE CAPABILITIES AND ECONOMIES OF AIR AND GASES

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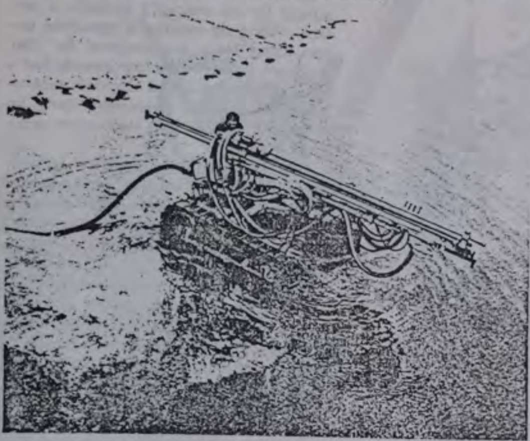
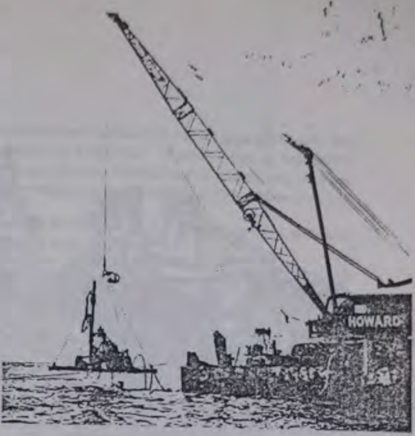
Drilling rig enters water in different ways, depending on the conditions. Close to shore, it moves into position as it would on land. Farther out, barge-mounted derrick was used to place Ingersoll-Rand Crawlair machine on harbor bottom. Mounted on this 400-ton barge was 600-cfm portable Gyro-Flo compressor to supply air for drilling.





View from shoals is of diver moving the Crawlair drill into position.

LAND DRILL

it is operating. At Amlwch, the divers needed a bull hose of 180 feet, three times the usual length. Air power to the drill was further tapped by water pressure. "You have about 20-psi water pressure at a 40-foot depth underwater," explains Duff. "Having lost 20 psi to friction, you lose another 20 psi to the water pressure. A pressure of 120 psig coming from the compressor ends up at about 80 psig."

To compensate, Duff attached a 40-foot hose to the hammer exhaust. As soon as the hammer started, air pressure drove the hose to the surface. Exhausting the hammer at the surface equalized surface and underwater pressures, cancelling the depth's influence.

Since the hose also eliminated one source of bubbles that annoyed the divers, Duff proceeded to eliminate the others, attaching hoses to the two air motors powering the tracks, the motor driving the hydraulics powering the bottom system, and to the exhaust from the main drifter feed. Finally, one more hose led from the hydraulics breather—a necessity. This one had to stay clear of the water altogether. It was tied to a free-floating buoy, which in turn followed the rig around as it drove back and forth on the seabed.

Work in earnest started in June 1974. The drillers grew so accustomed to their submarine working habitat that, visibility regardless, they routinely changed drill steels and performed other minor operating adjustments underwater. One suggestion by fascinated government industrial safety inspectors on the site produced a further 3-foot modification of the controls at the back of the rig. The inspectors were worried that, in the close underwater visibility, a diver tracking the rig might turn it upside down on an unseen obstruction, trapping himself underneath. The extension meant the divers had to walk behind the rig instead of riding on the platform provided, theoretically with more time to get out of the way. (In practice, say the divers, it is safer to stand on the rig because any "untoward movement" of the machine can then be felt at once. If the rig is about to topple, the diver can easily float out of the way. Everything underwater happens in slow motion.)

The salt water itself forced a last modification. The divers found they were habitually having to tighten bolts on the rig when it came out of the water. It turned out that the sea was acting as a penetrating oil, loosening everything. All bolts were then either wired tight or secured with a nonsetting gasket cement.

Five months after it started work in 8-hour shifts on the bottom of the harbor, the Crawlair had enabled 12,000 cubic meters of seabed to be blasted, 50 percent of it rock. Weather seldom inhibited the rig, which performed routinely in 30-mph winds and, as expected, tides had no effect. High winds and heavy swells did, however, hinder support to the drill from the surface, occasionally forcing a halt.

The working procedure goes thusly. To submerge the rig, a diver either drives it down a beach and walks underwater with it or hoists it overboard from an NCK 605 crane on a 400-ton steel pontoon stationed in the harbor. One diver at a time works underwater, wearing a standard dry suit and full face mask, with a single hose, two-stage regulator, and 30 pounds of belt lead. He is linked by 300 feet of air hose to two 180-cubic-foot air bottles on the pontoon, where a second diver is standing

Starting this year, however, Shell supertankers will unload oil at a single-buoy mooring 2 miles offshore. The site was chosen both as port for a fleet of tenders needed to service the tankers and as the point at which the oil pipeline will come ashore before running overland 80 miles to a Shell refinery at Stanlow in Cheshire, Wales. Precision Blasting, a subsidiary of England's Northern Rockdrillers, Ltd., was hired for the challenging drilling assignment to prepare for extensive harbor deepening required by the tanker mooring. Breakwater, piers, and spending beaches were required along with moorings for tanker tenders.

The deepening called for drilling 4-inch-diameter blastholes 20 feet deep along a 10-foot grid interval over 3500 square yards of harbor bottom to permit blasting to 30-foot depths in schist. Along with the saltwater environment, drilling was complicated by water depths under 15 feet, too shallow for pontoons to negotiate. The shoreline at points rises 50 feet, further complicating pontoon maneuvering. Then too, the harbor is subjected to stiff Irish Sea winds from the northeast and heavy tides, known to rise 25 feet, and as rapidly as 5 feet in an hour.

Accepting the unusually challenging drilling subcontract from general contractor John Howard (Northern) Ltd., Precision Blasting's first decision was to train four drillers to operate underwater with the skills of a diver, on the theory that no diver could be trained as quickly to duplicate an experienced driller's skills. Next, Precision Blasting's Jack Duff looked around for the concept's linchpin, a surface drilling rig capable of operating underwater. None are designed for that purpose. However, the firm already had a stock of Ingersoll-Rand Crawlair mountings. When Duff's divers were ready, he gave them one and sent them underwater to try it out.

The Crawlair rig drills vertical and angular primary blastholes in hard and abrasive rock. It travels on two five-roller tracks, each governed by an independent 7-hp motor, and is equipped with 10-inch-wide stability grousers.

The rig carries a hydraulically powered boom and drill guide to support and position a 4¾-inch URD475 hammer drill. The rig requires a portable compressor to supply operating air for the track motors, the hydraulics, the universal drill rotation, and the hammer itself. The compressor used is a portable DR600 Gyro-Flo. It is a two-stage machine, manufactured by Ingersoll-Rand Company and rated for 100-psig operating pressure at 600 cfm.

There was never much question of a hydraulically operated rig being used. Duff says that "with a hydraulic rig, you need a tube for every operation: one hydraulic pipe and a return for each hydraulic motor—up to four for each track, about 25 in the end; and then, you have air lock problems. You only need one tube with compressed air."

A hydraulic rig could have been used, he says, if the power pack were powered from the surface by compressed air, but standard compressed air equipment simply required far fewer modifications. Even water seeping into a compressed air motor presented no difficulties. It is blasted out when the motor starts.

Duff favored the rig he used because it is easy to set up and move around. No pins had to be removed, for example, nor do the cylinders have to be disconnected and reconnected when the guide is swung from horizontal to vertical.

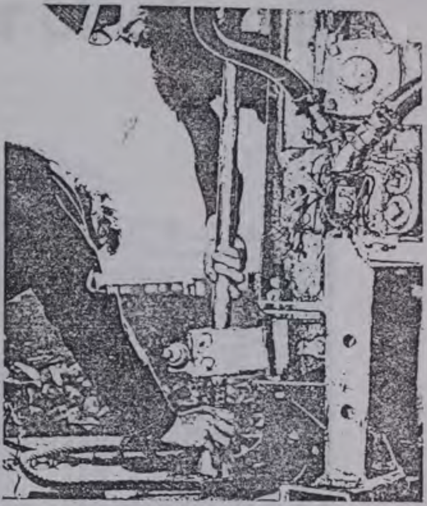
The Crawlair drill also offered a 14-mm flush tube inducting air through the hammer into the drill steel, twice as large as offered by some similar equipment. Duff considered this a key benefit. He also liked the penetration rate. Once the rig was modified, Duff worked it continuously at 120-psig pressure.

With first trials underwater, the divers found their problems lay with visibility and pressure loss. Much of the bottom of Amlwch Harbor is silt (Amlwch, in the Welsh language, means dust) and visibility ranged from difficult to none at all, forcing the men to work by touch. Every air-operated function in the crawler rig has to exhaust; the air bubble emission rendered even good visibility hopeless.

A certain amount of air pressure is always lost to friction as compressed air travels through a bull-hose link to the tool

Diver on ocean floor (left and on cover) gets set to sink first of daily series of blastholes. Rubber hose to lead drill's compressed air exhaust bubbles out of diver's way was one modification required to adapt I-R drill rig for submarine work.

Drillers (below) fit 4¾-inch bit to URD475 hammer drill prior to starting day's work.



. They are in constant telephone con-
t. If there is any chance of air hoses oming entangled with the rig in the se working quarters, the divers put on ba air bottles.

The first diver drives the rig along the floor to the approximate drilling site. e second diver watches the location of air bubbles from the pontoon. Since shot holes have to be sunk at a strict -foot grid interval across 3500 square rds of harbor bottom, white stripes inted on cliffs flanking the harbor were ed to locate the grid. To line up the ill precisely on shot-hole target, the ver on the pontoon sights the surfacing bbles against the painted markers and ues maneuvering directions over the lephone.

Shot holes are drilled up to 20 feet deep. aving drilled one, the diver moves the rig feet in a straight line and sinks the xt. Air flush combines with the water essure for highly efficient scouring. oles are either cased or charged immedi- ely after drilling to keep them from re- ling. The diameter of the average bore this job is 4 inches.

Blast danger to a fragile eighteenth-century pier and some stretches of ancient wall on the harbor perimeter, both regarded as historic relics, has required charges to be fired with electric millisecond-delay detonators. Early tests with Vibrograph readings showed maximum risk tolerance by the relics of 120 pounds of explosive. To accommodate this limitation, only ten holes or so are detonated at a time, each with an average 15-pound charge. The diver uses salmon floats to keep detonator leads in sight while he is setting the charges, fastening them 2 or 3 feet above the hole.

If the pontoon were used for any of the drilling, it would have to be withdrawn 200 yards from a blast to avoid damage. This maneuver means easing and winching four steel cables, probably in unfavorable weather. It means a tug standing by to help. In toto, it would be a tedious, time-consuming operation. The Crawlair rig on the bottom is not subject to any risks, there being no flotation seams, as on the pontoon, to spring. When a diver has prepared a detonation, he simply backs the rig 10 feet from the nearest shot hole and goes back to the pontoon, leaving the rig on the bottom.

At the end of an 8-hour day, the Crawlair rig is driven or hoisted out of the water. Fitters then operate all motors at full-cock, discharging sea water instantaneously. It has been found advisable to change the hydraulic oil and strip the pneumatic hammer more frequently than would be required in surface work, however this is done as "an ounce of prevention." Otherwise, the only special maintenance found necessary has been a daily, thorough wiping down of the whole rig with oil to protect it against corrosion. So far, a spot of rust on the chrome of the rig's hydraulic boom chamber marks its only concession to its 9 months in salt water. (The rig was 8 years old when it went to work on this assignment.)

Perhaps the ultimate lesson learned from the Amlwch Harbor drilling experience is that drillers should not be deterred from trying the different or the unusual when a job requires a novel approach. Precision Blasting did, and the results made the harbor deepening job far faster and more efficient as a result.

goes back to the pontoon, leaving the rig on the bottom.

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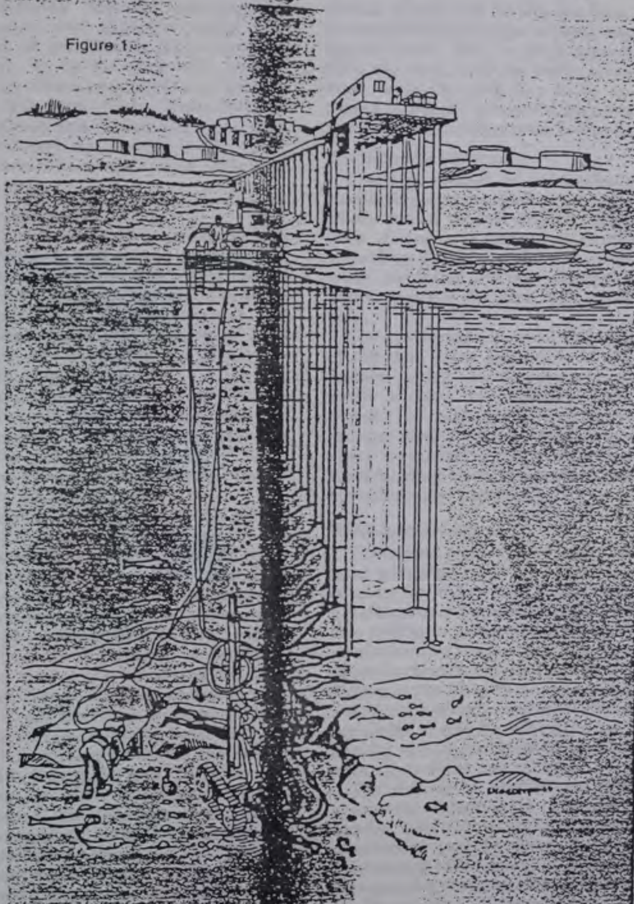
CAUTION!
Underwater blasting i

Figure 1



DIVERS DEEPEN an are
crawler drill such as an A
This technique is used
In relatively shallow wate

progress

Blasting requires considerable caution and expertise under the best of conditions. But when the work is to be conducted underwater, there is an additional hazard to life and limb. Nevertheless, methods and procedures have been developed to handle such operations in a safe and efficient manner.

by Björn Kihlström

THE TREND toward larger ships, particularly in tankers and bulk carriers, has increased the demand for deeper harbors and ship channels all over the world. And because channel and harbor floors often consist of hard rock, the deepening has to be performed by blasting.

Oil and gas pipelines from offshore terminals need protection from the elements, and underwater trenches offer one way of protecting them. And here again underwater blasting may be necessary.

Often, blasting has to be carried out close to sensitive structures and installations so that blasting operations must be carefully controlled. The vibration hazard is more severe underwater and shock waves more readily transmitted. In short, careful calculation is required to determine the size of the round and the most appropriate blasting method to use.

There are three principal methods for performing underwater blasting: (1) By having divers do the drilling with hand-held rock drills or with crawler drill equipment on the seabed. The divers would also do the charging. (2) By drilling and charging operations carried out from the surface, either from a floating raft, or from a platform on legs or spuds. The latter eliminates the effects of the tides, waves, and currents. (3) By placing suitable amounts of explosives in a quadratic pattern on the surface of the rock on the sea floor. Concentrated chargings without any specific form, but in good contact with the rock, may be used. However, when the rock has to be removed to a depth of several meters a special type of charge must be used.

Björn Kihlström *is chief consultant with Nitro Consult AB of Stockholm and has an international reputation for solving delicate underwater blasting problems.*

When to use divers

The first method is economically practicable only in small-scale operations and at modest depths. However, divers have worked at depths exceeding 200 m for short periods, when saturated diving equipment and a pressure chamber were available.

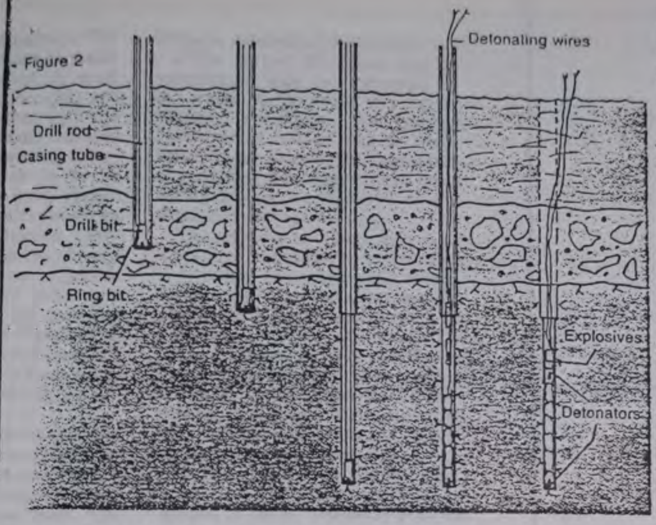
The comparatively small diameter of the drill holes put down in this fashion result in correspondingly small amounts of explosive being placed. The small cooperating charge reduces ground vibrations and water shock waves and is suitable for cautious blasting close to sensitive construction. (See Figure 1.)

Rafts and platforms

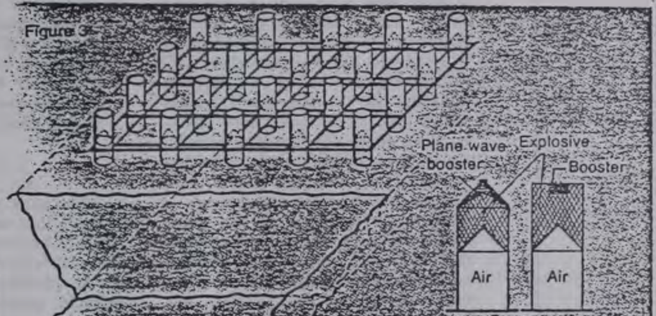
The second method is probably the most commonly used in underwater blasting for harbor deepening, channel clearance, and pipeline trenching. The drilling is performed from a raft or platform on the surface. The type of platform used depends on the conditions at the site. In narrow canals and those having considerable boating traffic, it may be difficult to use a floating raft or an elevated platform with all its wires and anchors.

The drilling is carried out with equipment adapted to the overburden. Guide tubes are used for the overburden part to steer the drill steel during collaring and to keep the hole open for charging. Prefabricated cardboard pipe charges having a diameter of more than 50 mm and a length of more than 600 mm are used.

The Overburden Drilling Method developed in Sweden for underwater drilling from a platform, is a further development of the guide tube method. (See Figure 2.) The drilling equipment consists of an outer casing tube with a ring bit of cemented car-



OVERBURDEN DRILLING method makes use of a casing tube to guide the drill and to simplify charging. The tube is withdrawn once the explosives and detonators are set in the bedrock borehole.



SPECIAL CHARGES are set in a pattern atop the bedrock to blast out a trench. Note cone configuration which serves to force the energy of the explosion downward in each charge.

hole at the lower end, and an inner drill steel with a cross bit. In most cases the drilling is performed with only the casing tube equipped with a ring bit through the overburden and 30 to 50 cm down into the rock. The drilling through the rock down to the desired depth is performed with the inner drill steel with the cross bit. The casing tube remains in the hole and serves as a channel for charging. Once charging operations are finished the tube is removed.

Because of the hazard of drilling into a charged hole, a new hole should not be drilled nearer than 2 m from an already charged one. When the hole spacing is less than 2 m the whole ready-filled round is loaded at the same time through plastic tubes with the same outside diameter as the drill holes. Gelatine explosives of the dynamite-type are used, either as prefabricated cardboard pipe charges or cartridges. By using pneumatic cartridge chargers it is possible to obtain the theoretical degree of packing. The charging procedure generally calls for two detonators with the same delay number—one at the bottom and one in the column charge. In deeper drill holes, three to four detonators may be necessary to prevent undetonated explosives from remaining in the round, thereby reducing the result of the blasting.

Surface rock blasting

The third method is used when drilling is inconvenient or impossible. Usually, a thin layer of rock covers a very soft rock or sand or clay. In such cases, concentrated explosive charges are placed on the sea floor,

in a quadratic pattern. The must be resistant to water nsiderable period; it must igh detonation velocity, and be in good contact with the rounds are usually initiated neously by detonating fuse.

he a deep trench is to be n homogenous rock, special ter explosive units should be achieve the desired deep- nd fragmentation. These are usually metal or plastic s divided in two parts by a one with the tip pointing . The explosive is packed on r side of this metal cone; the neath the cone is enclosed to water from entering the cyl- See Figure 3.)

the explosive detonates, the ne is hurled toward the lon- l axis of the cylinder, there- cting the explosive energy rd into the sea floor. The charge explosive energy is so l that the rock can be crushed th of approximately 5 m. The epends on the magnitude of rges. These charges are gen- ysed for producing underwater trenches or for clearing the r. Blasting by this method owever, cause serious ground ns and water shock waves in roundings.

us blasting

oint blasting is very common n built-up areas and close to g power stations and tunnels, blasting can be carried out in y and where visibility is un- rted. In underwater blasting r, there are pressure prob- d visibility is generally lack- is therefore important to find erything possible about the hrough preliminary investi- s, such as test drillings and c exploration. It is particularly ant to follow the drilling work arefully and to record all the s in the rock, whether they are open, filled with clay, and so

ured rock can result in flash- between adjacent drill holes different delays. Because the t of explosives being simul- sly initiated exceeds the calcu- s, greater ground vibrations ock waves than anticipated will Flash-over often leads to r vibrations, inferior fragmen- , and a breakage of the rock le the calculated contour.

sequently, pinpoint blasting s blasting to keep the ground tions, the water shock waves, he breakage within permissible limits as determined by the site.

- The ground vibrations from an underwater blast can generally be calculated in the same way as for blasting elsewhere. The risk of flash-over in case of clay or water fissured rock stresses the importance of recording the observations made during drill work and taken into consideration during charging.

The only way to reduce the ground vibrations from underwater blastings is to reduce the cooperating charge. In the case of large rounds, the time needed for the vibrations to reach the vibration sensitive structures can cause interference and result in a lower vibration level than the cooperating charge alone should have caused. This can be effected through the performance of careful ground investigation and calculation.

- The underwater shock waves arise from the detonation of an explosive in water. The most powerful shock waves occur when the explosive is suspended free or lying uncovered on the sea floor. Explosives enclosed in drill holes give rise to considerably smaller shock waves than charges which are not enclosed. The enclosure and the breakage of the rock by the detonating explosive reduces the maximum pressure of the shock wave only 10 to 14% of the maximal pressure of a shock wave resulting from the detonation of an explosive hanging free in the water.

The maximum pressure of a shock wave can be reduced to a considerable extent by using an "air bubble curtain" in the water. The magnitude of the weakening effect depends upon the quantity of air released per second and per meter. However, the impulse of the shock wave is not moderated. The protective influence of the "air bubble curtain" system is therefore questionable, because even though the maximum pressure is reduced, the protection of the shock wave is longer. A transitory shock wave with a high pressure can cause less damage on a structure than a shock wave with low pressure but a long-term effect. The influence of the impulse on the construction can only be stopped by using a shield.

- To prevent breakage of rock beyond the limits prescribed is another important aspect of underwater blasting that calls for control as, for example, when deepening of waters close by a quay.

Smooth blasting can be carried out about the same way as by surface blasting, and even presplitting is possible.

Presplitting requires that certain precautions be observed. There is no burden to be blasted away, but the

explosive gases are enclose drill holes and the pres fissure. If the rock is fissur taining clay, earth, or wat shock waves from the blastir through these fissures and ca ground vibrations differin those calculated. In most cas ever, the influence of the bla the surroundings can be kep control by careful obser during drilling and chargin ations, and by monitoring the vibrations and shock waves.

FILE

BLASTING JOURNAL

The Voice of the Blasting Industry

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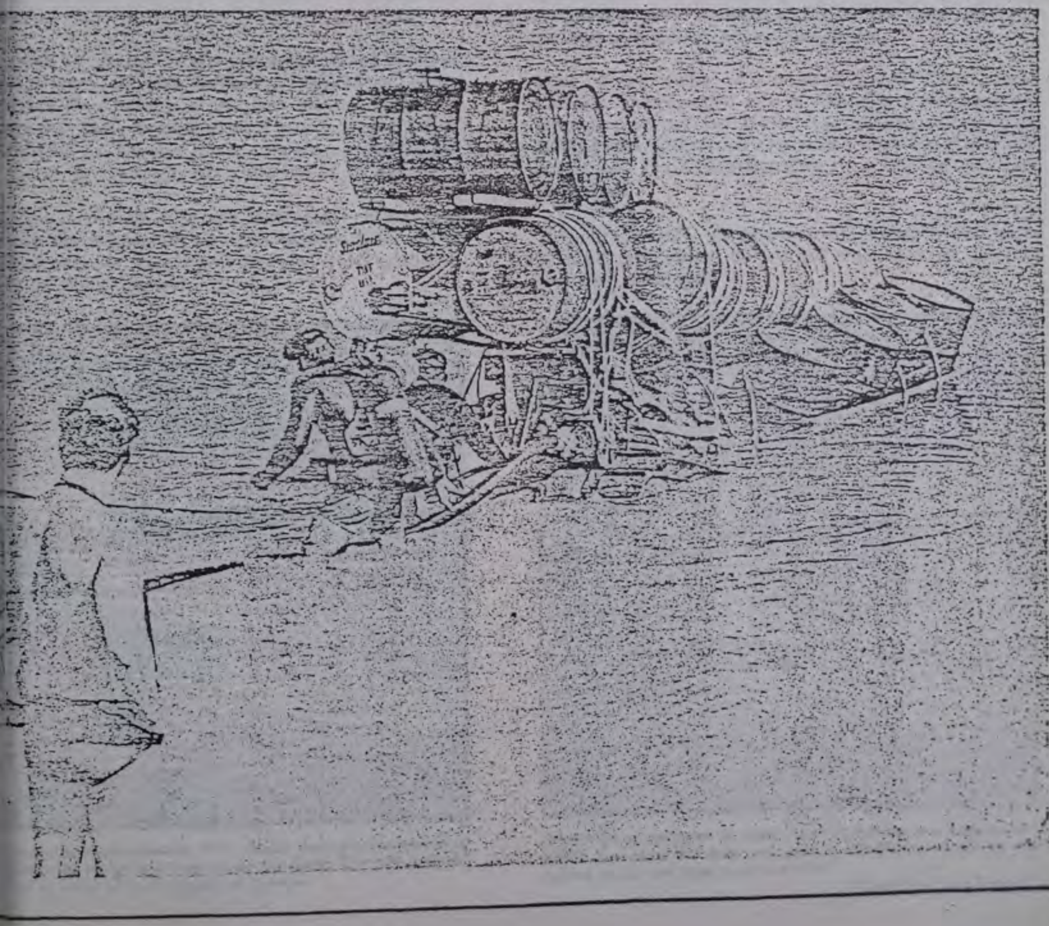


FACTORS IN SUBSEA BLASTING

by Albert Teller

Teller is president of the International Society of ...ves Specialists. He is vice president of Explo- ...ternational, a blasting contracting and consulting ...ecializing in underwater and demolition projects. ... delivered technical papers on explosives at the ...d Engineering Conference, Trondheim, Norway, ... Society for Building and Construction in Hungary. ...ly authoring a book on blasting between consult- ...s and contracting work, he is a resident of Issa- ...ash. Teller is a member of the American Society ...ty Engineers and holds a masters degree from ...University.

...) years of blasting, much of it underwater, it is ...ession that most blasters know little about diving ...st divers know little about blasting. There are ...ly few men who have specialized in underwater ...

...most axiomatic in the construction and dredging ...sies; when all else fails, use explosives. Never ...nless there simply is no other way out. When one ...ers that there is more energy in one small stick of ...ite than in several dozen rippers or cuttherhead ...s, one wonders why this attitude is so prevalent.

...ason is not too difficult to discover. Which ever ...irst, the chicken or the egg - there is little use of ...ives because there are so few men really qualified, ...ally, to do the work.

Yet the technically sound application of explosives is not only economical but efficient.

First apparent costs may seem high, but on most projects, the overall cost of properly-applied use of explosives is much less than without their use - referring now not only to those projects where explosives must be used, but on projects where explosives could be used.

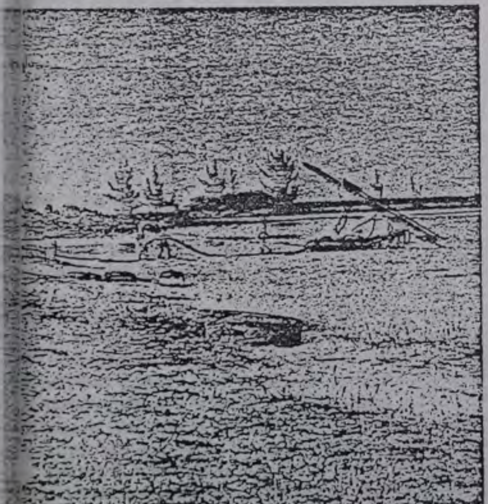
USED OR MISUSED?

It is well to remember that on those projects where explosives must be used, too often they are misused or misapplied.

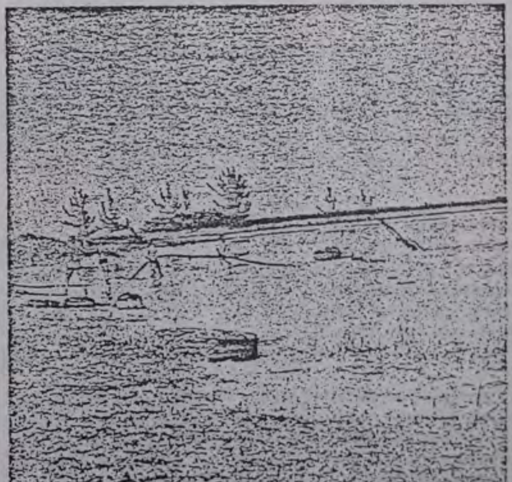
In 1961 on an island in the Pacific, hundreds of metal beams and dock supports were being eaten away by undersea growth and erosion due to weathering at the splash zone. The problem: devise a method of cleaning the pilings, place concrete at the splash zone and save the cost of replacing pilings and docks.

First, divers using wire brushes proved futile. Sand blasting, entailing the use of divers and compressors, attempting to get the blown sand on the piling while holding fast against currents and waves - difficult and dangerous - proved unsuccessful. The next try was with explosives.

Ten pilings later, all blown over, damaged, with parts of the dock thrown in the air and other mishaps, the project was abandoned.



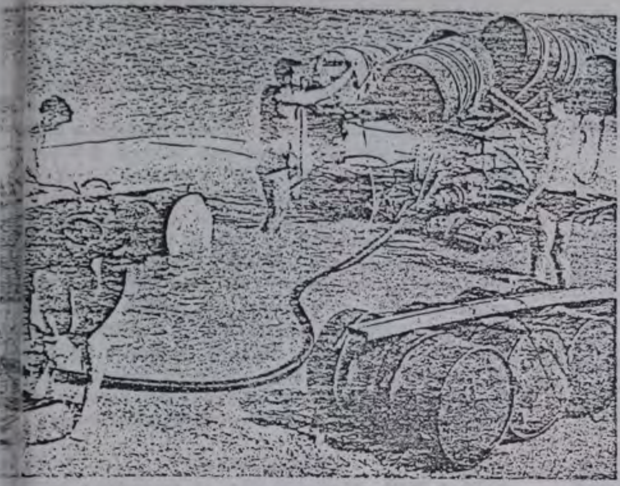
...ake site at Homestead, Fla., Navy demonstration presented ...problems, including a very steep shoreline. The drill operated ...feet of water without adaptors or changes.



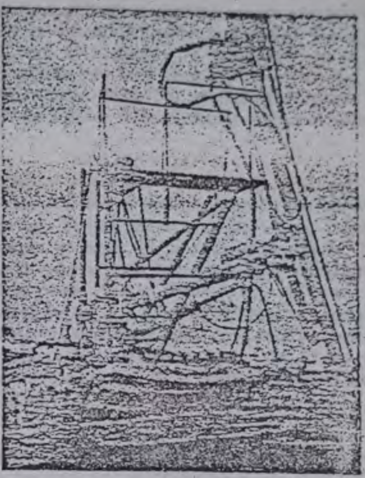
Even with no equipment to lower the drill into the water the project proved successful and later was used in the Atlantic Ocean off the Azores to drill and blast a cable trench.

Continued on Page 7

...A BLASTING - *Cont. from Page 3*



...nderwater drilling demonstration for the U.S. Navy, a three-ton Worthington drill ...re floated out and lowered gently into the water. The feat was accomplished with ...of 55-gallon tanks fastened to the underwater tractor drill, then flooded.



Underwater Ingersoll-Rand C-2 tractor with a drill, rigged to be driven into the Mississippi River. In spite of near-freezing temperatures, drill worked efficiently.

...point, a research project was started at Honolulu. ...sives - Hawaii (now Explosives International, ...ah, Wash.) took on the study to see if the use of ...ives could safely remove the incrustation from ...surfaces underwater. Results were "perfect re... complete safety."

SHOCK EFFECT

...rocess developed used the shock effect of deto... cord, carefully placed inside the web of the ...s. Every effort was made to avoid direct contact ...etal, and to allow pressure and shock waves to do ...rk. This technique will clean hulls of ships and ..., incrustation from sea walls, metal caissons and ...pipes. That the process could be developed is not ...elf astounding. What is astounding is that no one ...one it before, and even more is that no one does it ...Our company has used the technique only on rare ...ions. We have had little call for its application, ...we are perfectly aware that there are many uses ...is particular technique.

...lly blasting river crossings, reefs, channels, and ...ke is pretty much a cut and dried process. Once the ...ct is under way, drills are mounted on barges, holes ...rilled, and powder loaded through the drill stems or ...gh casings. It is a tedious, laborious job, haphazard ...xpensive. Yet this is the standard method of drilling ...blasting for any type of underwater project. It is ... the most economical nor the safest. To the con... it is fairly dangerous, particularly if movement of ...arge is required from time to time. A drill which is ...d and then wrongly repositioned can, and has, ...ed detonation of the explosives already loaded, with ...tant damage and loss of life.

A portion of the Mississippi River was drilled and blasted from the top of an Ingersoll-Rand C-2, rigged with a platform. Controls were moved with the use of hydraulic hoses and the entire operation was performed by a driller from the platform. The weather was unbearably cold and ice floes posed a constant problem. The drill worked very efficiently and, though a diver was required to load the holes, even this was accomplished with a minimum of delay and effort.

Assembling a barge and floating it down-river would have cost almost as much as the whole drilling and blasting operation with a "swimming" drill. Although efforts to keep the drill from freezing consumed a great deal of time, as many as 50 10-foot holes were drilled in a six-hour day, and 600 yards of rock per day was realized.

ONE DRILL

This method entailed one drill, a 600 cfm compressor, one driller, one helper and one diver. Explosives were kept on the platform with detonating cord payed out and the correct distance maintained by measuring the amount of cord. The operation saved the prime contractor many thousands of dollars. Rigging platforms and attendant problems are not always required.

Early in 1962 Explosives International used a fully submerged drill to blast a reef in Hawaiian waters. Since that time it has become a more frequently used technique. Air track drills, the kind normally used on rock projects on the surface, are modified to function below the surface of the water. Air vents are manifolded to the surface by air hose. Hydraulic systems are also vented to the surface, and the exhaust ports from the drifter and the air

Continued on Page 12

-EA BLASTING - Cont. from Page 7

ors are vented similarly. Other than these changes, ch can be accomplished in a few hours, no others l be made. Holes are loaded by a diver or the operator ne drill, if he is qualified to do so.

970 a demonstration of underwater drilling was made the U.S. Navy at Homestead, Fla. Explosives Inter-onal was awarded a "sole source" contract to prove feasibility of the technique for future Navy use. The blems presented were many. First, there was no pment available to lower the drill into the water. The re line of the lake, in which the demonstration had be conducted, was very steep, thereby demanding ethod of floating the three-ton drill into the water, vly lowering it to the bottom. The feat was accomp-ed by strapping 55-gallon tanks around the drill, mming it into deep water, and floating the tanks. The re process was later used in the Atlantic Ocean, off Azores, in the drilling and blasting of a cable trench.

CALCULATIONS

lling underwater is very expensive. From a barge, ts in excess of $2 per cubic foot are not uncommon. n a drill in the water, this cost can be cut by some percent. When calculations are made, drill spacings depth of hole, water involved, pay line and quantity powder able to be placed in a single hole must be sidered.

with drilling holes on the surface, burdens and spac-s must be calculated. Certain rules of thumb may be d. Burden and spacing should be nearly equal but in case, the spacing always should be equal to, or ger than the burden. Spacing between holes should er be more than the depth of the hole. In underwater sting, more explosives have to be placed in the hole the depth of the water increases.

calculating removal of six feet of rock under 25 feet water, the depth of the water should be assumed to be half the weight of the rock. For a surface trench 20 t wide, six-feet deep and 100-feet long, holes can be ced on six-foot centers with each accommodating a al of 16 pounds of dynamite.

CALENDAR OF EVENTS

bruary 8 - 10

5th National Western Mining Conference and Exhibition, enver Hilton Hotel, Denver, Colorado. Exhibits and apers on: Mining, Milling, Public Lands, Geology, Coal, ealth & Safety, and General Session (discussion) on nvironment.

ponsored by the Colorado Mining Association, 402 Maj-stic Building, Denver, Colorado 80202. (303) 222-0889.

bruary 12 - 16

xhibition space is still available for the Second Annual Conference on Drilling and Blasting sponsored by ISES.

Contact Marvin Pope, Convention Chairman, Del Webb Towne House, Phoenix, Arizona.

Underwater, instead of basing calculations on six feet of rock, 18.5 feet is calculated with 23.4 cubic yards of rock assumed, and 17.5 pounds of explosives used in each hole. By adding two feet of sub-drill, or a total of 11 feet of hole, allows more than enough explosives to break the rock and move it sufficiently for excavation.

DRILLING SAVES

It is in the drilling where the savings can be found. If, as is normal with six feet of rock, drilling is on four-foot centers, holes are drilled eight feet into rock. (double spacing for depth of hole). A 20-feet wide trench, 100 feet long, would require 1000 feet of drilling on six-foot centers, 11-feet deep drilling three holes wide and 16 long. Eleven feet depth, or a total of 528 feet is required. With costs of $2 per foot there is a considerable saving. The drilling cost is just about one half. This is a small trench. Consider excavation of a harbor 500-feet wide, by 1000-feet long.

The calculation of the water into the problem is a relatively simple process, but in most cases this calculation is rarely made. Whether or not drilling is done from a barge, or with a drill submerged is not at issue. There are certainly circumstances where a drill underwater is not feasible.

NEW EXPLOSIVES

New explosives called "slurries" lend themselves especially well to underwater work. They are, first of all waterproof, and will withstand great pressures withou deterioration. They are safe to handle, and easy to use They have densities in excess of 1.3, and therefore will sink in water. They will not "float" out of holes, and will remain fixed into place.

Slurries fill the entire borehole, and there is not annula space loss. Most slurries are less expensive per poun than standard cartridged dynamite.

Slurries rarely are "cap sensitive". That is, they wil not detonate if initiated with a blasting cap only. In thi regard there are advantages and disadvantages.

They are usually not classified as Class "A" explo sives (cap detonable), and require less sophisticate means of storage and transportation. High velocit primers are required to bring them to their peak velocity

Primers which are classified as "HDP" (high densit primers) are always waterproof, simple to handle, an will detonate when initiated by a blasting cap or piec of detonating cord. Often times slurries can be brough to detonating velocity with the use of a large detonatin cord, thereby eliminating the need for a cap primer. The are probably the blasting agent of the future where larg underwater blasting projects are encountered.

Underwater blasting is a specialized field, which re quires those in it to be highly qualified in the use of ex plosives, and thoroughly trained in the special physic of underwater work. They must be specialists in eve sense of the word.

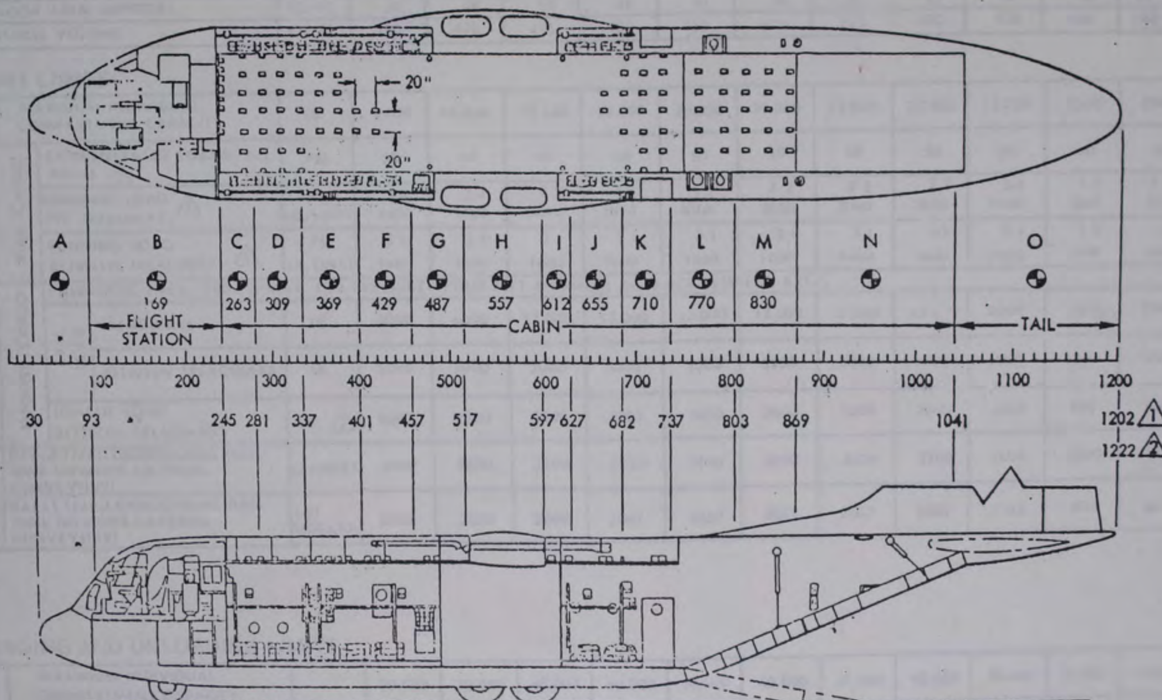
SECTION 5 : PORTABILITY OF RIG AND COMPRESSOR

The total operational weight of the LM100 rig, fitted with the YD90 drill, is 5400 lbs (2450 kgs) and occupies a volume of 260 cub.ft. (7.3 cub.m.). Likewise, the P375SD compressor has a weight of 4232 lbs (1920 kgs) and occupies 396 cub.ft. (11.2 cub.m.).

Consequently, lighterage from ship to shore would need to be conducted using a combination of the one tonne capacity barges connected together to form a pontoon capable of handling 2.5 tonnes. This will accommodate the rig initially and secondly the compressor and other ancillary items on a separate voyage.

Also for your information are details of the Hercules C-130A aircraft compartment loading limits, should you be in a position to airlift the units.

Once on shore, the rig can be driven under its own air supply to a suitable storage area and consequently to your drilling site.



NOTE

THE LAST ELEVEN INCHES OF COMPARTMENT M IS NOT FLOOR SPACE

1 C-130A AIRPLANES AF53-3129 THROUGH 57-509.

2 C-130B AIRPLANES AF57-525 AND UP; CG-1339 AND UP.

Figure 2-4. Compartments (Airplanes AF53-3129 through 57-509; 57-525 and Up; CG-1339 and Up)

GENERAL

1	FUSELAGE STATION		245 281 337 401 457 517 597 627 682 737 803 869										
2	COMPARTMENTS		C	D	E	F	G	H	I	I	K	L	M
3	FLOOR AREA (APPROX)	SQ FT	31	48	55	48	51	68	26	47	47	56	56
4	USABLE VOLUME	CU FT	280	430	495	430	460	610	235	420	420	450	280

FLIGHT LIMITS

1	MAXIMUM INDIVIDUAL COMPARTMENT CAPACITY		LB	8400	12,900	19,500	28,000	30,000	30,000	15,000	24,400	12,700	2500	2500
2 ⚠5	BULK CARGO	CONCENTRATED LOADS - ALL AREAS ⚠3	PSI	50	50	50	50	50	50	50	50	50	50	50
		RUNNING LOAD PER TREADWAY ⚠1	PSI LB/LINFT	3.4 1400	3.4 1400	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	3.4 1400	1.2 500	1.2 500
		RUNNING LOAD BETWEEN TREADWAYS ⚠1	PSI LB/LINFT	3.1 1400	3.1 1400	3.1 1600	3.1 1600	3.1 1600	3.1 1600	3.1 1600	3.1 1600	3.1 1400	1.3 500	1.3 500
3 ⚠6	WHEELED CARGO	PNEUMATIC TIRES - 100 PSI MAX. TIRE PRESSURE - FOUR FEET MINIMUM DISTANCE BETWEEN AXLES												
		AXLE LOAD: TREADWAYS	LB	6000	6000	13,000	13,000	13,000	13,000	13,000	13,000	6000	2500 ⚠8	2500 ⚠8
		AXLE LOAD: BETWEEN TREADWAYS	LB	5000	5000	5000	5000	5000	5000	5000	5000	5000	1200	1200
		TONGUE LOAD BETWEEN TREADWAYS	LB ⚠2	2000	2000	2000	2000	2000	2000	2000	2000	2000	450	450
4	PALLETIZED CARGO-DUAL-RAIL (ONE OR MORE LATERAL CONVEYORS)		LB/LINFT	2800	2800	3200	3200	3200	3200	3200	3200	2500	1000	1000
5 ⚠7	PALLETIZED CARGO-DUAL-RAIL (ONE OR MORE LATERAL CONVEYORS)		LB/ROLLER	2333	2333	2667	2667	2667	2667	2667	2667	2333	833	833

LOADING AND UNLOADING LIMITS

1	MAXIMUM INDIVIDUAL COMPARTMENT CAPACITY			20,000	30,000	40,000	40,000	40,000	40,000	37,000	40,000	30,000	26,000	26,000
2	BULK CARGO	CONCENTRATED LOADS - ALL AREAS ⚠3	PSI	50	50	50	50	50	50	50	50	50	50	50
		RUNNING LOAD PER TREADWAY ⚠1	PSI LB/LINFT	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000	7.2 3000
		RUNNING LOAD BETWEEN TREADWAYS ⚠1	LB/LINFT	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800	6.7 2800
3	WHEELED CARGO	PNEUMATIC TIRES - 100 PSI MAX TIRE PRESSURE - FOUR FEET MINIMUM DISTANCE BETWEEN AXLES												
		AXLE LOAD: TREADWAYS	LB	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
		AXLE LOAD: BETWEEN TREADWAYS		5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000

SECTION 6 : PRODUCTION CAPABILITIES

Enclosed in this section is a summary performance and output potential chart for the LM100 drill rig, fitted with a YD90 drifter drill and powered by a P375SD portable air compressor.

The chart is based on assumptions, since actual ground conditions are not available.

We have based our calculations on biostromal limestone, which is an organic limestone derived from sedentary organisms such as occur in coral limestones. It is understood the rock is competent and good to drill, leaving a clean "shiny" hole.

We have suggested 2.5" (62 mm) diameters since it will be difficult to contain any blast in holes bigger than this with the shallow depths you intend to drill. Using this size hole, a drill pattern of 6' x 6' will achieve a fragmentation size easily transportable by hand.

However, depending on conditions actually encountered, will depend on actual patterns used. Nevertheless, it is believed our suggestions will be a good bench mark.

SUMMARY
PERFORMANCE & OUTPUT POTENTIAL

PROJECT TOKELAU ISLANDS

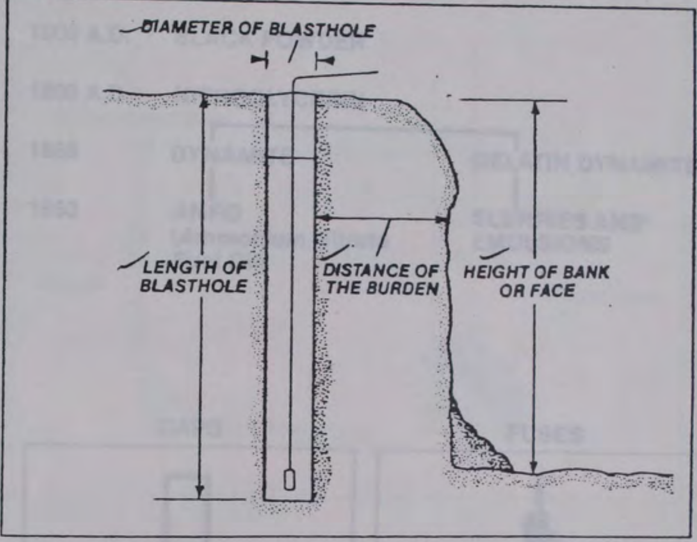
ROCK CONDITIONS		BIOSTROMAL LIMESTONE 15-20,000 PSI					
PRODUCTION TARGET							
EQUIPMENT		INGERSOLL-RAND LM100/YD90 RIG, P375 COMPRESSOR					
BIT DIAMETER		2.25" (57 MM)					
BENCH HEIGHT	ft	3.5					
	m	1					
HOLE ANGLE	°	–					
PAY HOLE DEPTH	ft						
	m						
BURDEN	ft	6					
	m	1.75					
SPACING	ft	6					
	m	1.75					
SUB GRADE	ft	5.0					
	m	1.5					
TOTAL DEPTH	ft	5.0					
	m	1.5					
YIELD PER HOLE	yd^3	4.66					
(SOLID)	m^3	3					
YIELD PER HOLE/FT	yd^3	1.33					
YIELD PER HOLE/METRE	m^3	3					
AVERAGE PENETRATION	in/min						
SPEED OVER HOLE	cm/min						
PENETRATION RATE	ft/hr	100					
	m/hr						
TIME ACTUALLY DRILLING	mins	5					
ROD/TUBE HANDLING @ ...... mins each		N/A					
MOVEMENT HOLE-TO-HOLE	mins	3					
LINE UP AND COLLAR	mins	3					
TOTAL TIME PER HOLE	mins	11					
CONTINGENCY FACTOR 10%		1.1					
OVERALL TIME PER HOLE	mins	12.1					
OVERALL DRILLING RATE	ft/hr	42					
	m/hr						
INDUSTRIAL 'B' FACTOR 10 %		5					
EFFECTIVE HOURS PER 10 HOUR SHIFT		9					
INDUSTRIAL DRILLING RATE	ft/hr	37.8					
	m/hr						
HOLES PER HOUR PER RIG		7.5					
YIELD PER HOUR PER RIG	yd^3	35					
	m^3						
YIELD PER SHIFT	yd3	315					
EXCESS OVER TARGET							
% EXCESS POTENTIAL							

1-7

The Purpose of a Blasthole . . . Distribute Explosives in Rock

A

THE IMPORTANCE OF ACCURATE MEASUREMENTS

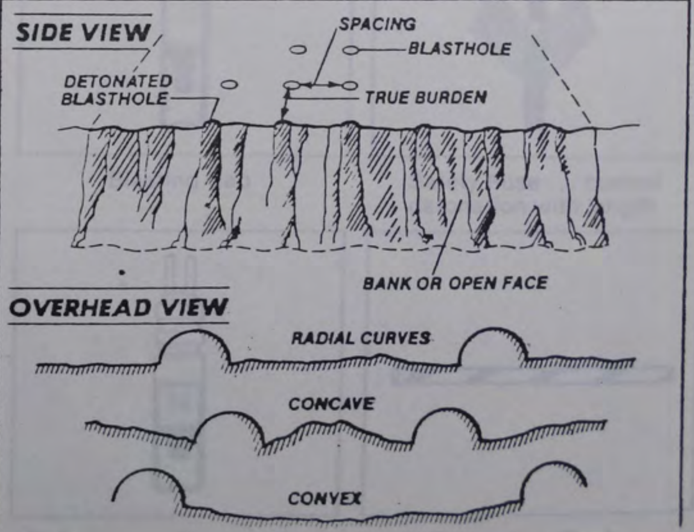


B

A TYPICAL DRILL PATTERN

1. True Burden

2. Spacing Blastholes



1-10

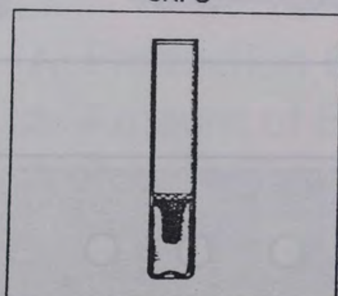
The History of Explosives
A Thumbnail Sketch

A
TIME LINE

1000 A.D.	BLACK POWDER	
1800 A.D.	NITROGLYCERIN	
1866	DYNAMITE	GELATIN DYNAMITES
1950	ANFO (*A*mmonium *N*itrate *F*uel *O*il)	SLURRIES AND EMULSIONS

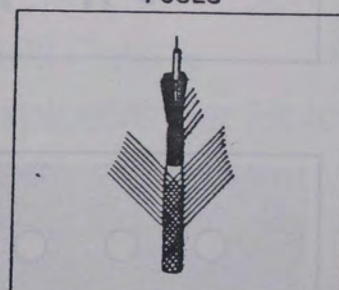
B
EXAMPLES OF DETONATORS

CAPS

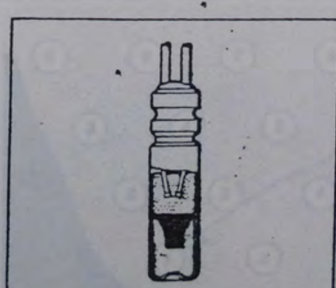


Blasting Cap

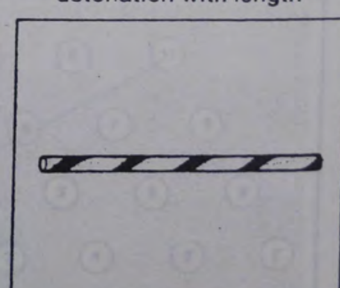
FUSES



Safety Fuse . . . control detonation with length



EBC (Electric Blasting Cap)

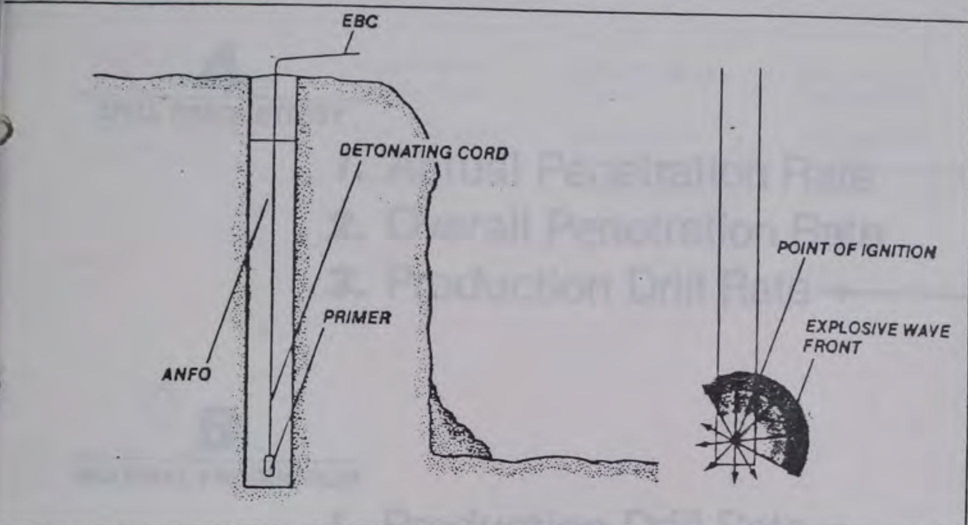


Detonating Cord

1-11

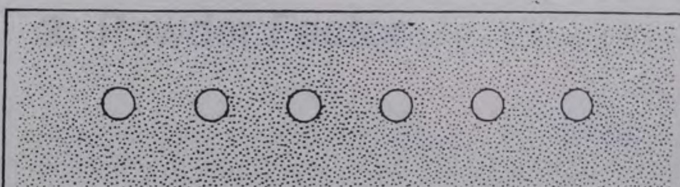
The Dynamics of the Explosion

A



B

THE MULTIPLE HOLE BLAST

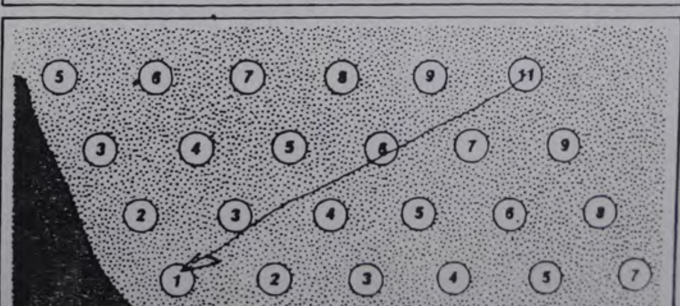


The Delayed Blast

Every hole should be detonated at a different time than any adjacent hole.

he tight hole or holes at he end of any row must be detonated later than the adjacent hole.

Rock movement of the complete blast will be toward the first hole detonated and away from



1–13

Production Basics

A
DRILL PRODUCTIVITY

1. Actual Penetration Rate
2. Overall Penetration Rate
3. Production Drill Rate

B
MATERIAL PRODUCTION

1. Production Drill Rate
2. Amount of Explosive per Hole
3. Powder Factor

1–14

Rock Types

A

GENERAL DESCRIPTION	Very Heavy, Strong Rock	Intermediate Rock	Very Soft, Weak Rock
GEOLOGICAL DEFINITION	Hard Igneous, Diorites Granites	Medium-to-Hard Limestones, Soft Igneous	Soft Shales, Weak Sandstones, Soft Limestones

B

DRILLABILITY AND PRODUCTION FACTORS

1. Consistency	Varies with local formation . . . *ask drillers and superintendent*
2. Unconfined Compressive Strength	Drill and explosives must overcome material's unconfined compressive strength
3. Abrasive Index	Varies with grain size and structure . . . *obtain samples for testing*

SECTION 7 : DRILLING ACCESSORY USEAGE

The nature of the Tokelau exercise will have a small requirement for drill accessories.

The drill rods can be expected to have a good 1½ times the normal life since only half the rod is being used in the hole. However, sea water may have an effect on the thread life. Similarly, couplings, because the material is soft, which take little wear and a good life can be expected. Shank ends should also have an extended life. Drill bits may take on a certain amount of annular wear at the bit body, with the wear constant from water and limestone mix, causing a mild grinding paste.

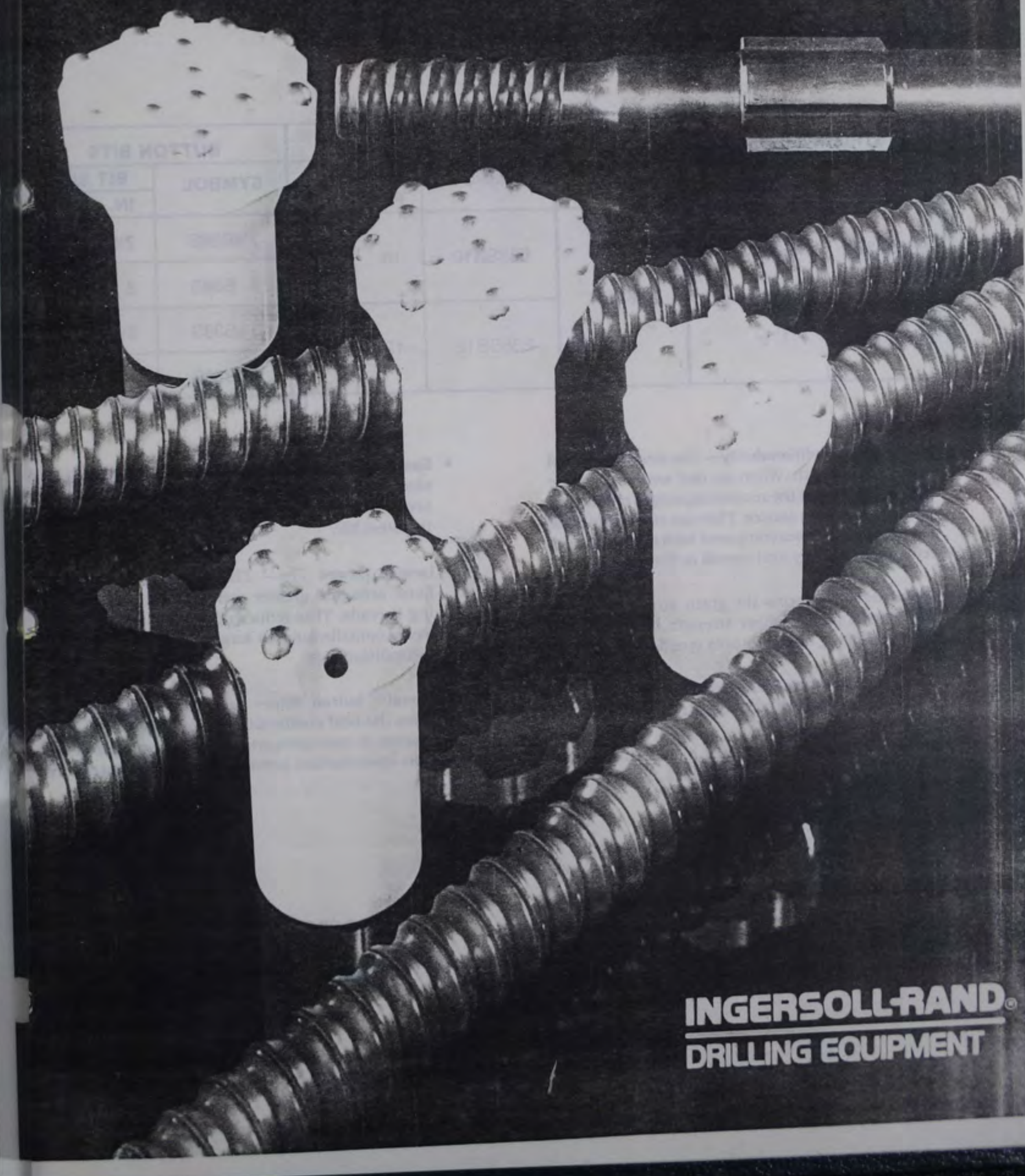
It is recommended that the following be carried on the project site.

(A)	Shank ends	3
(B)	10' drill rods	5
(C)	Couplings	10
(D)	2-1/4" button bits	5

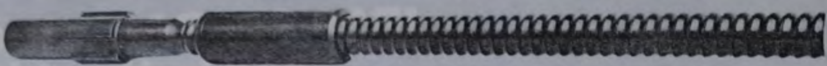
In order to achieve maximum life from your accessories, a good quality thread grease must be used.

IR38 SPI-RAL® steel and button bits

Patented full-length lubricating groove



INGERSOLL-RAND®
DRILLING EQUIPMENT



Ingersoll-Rand IR38 Spi-Ral® Steel System: Up to 4″ (102-mm) holes

STRIKING BAR		COUPLING SYMBOL	38 mm DRILL STEEL			BUTTON BITS		
SYMBOL	DRIFTER MODEL		SYMBOL	LENGTH		SYMBOL	BIT SIZE	
				FT.	M		IN.	MM
SB38S3B	VL-120/140	C38SBB	E38SB10	10	3.1	2½B38S	2½	63
						3 B38S	3	76
SB38F17A	F-170		E38SB12	12	3.7	3½B38S	3½	89
						4 B38S	4	102

- **Full length reconditionability**— The steel is threaded over its full length. When an end wears, it can be simply cut off and the remaining length chamfered and put back into service. This can extend steel life as much as six times compared with ordinary steel, reducing inventory and overall drilling costs.
- **Rolled thread** reforms the grain structure of the steel, giving greater shear strength than with cut threads. Rolling also improves tensile strength.
- **Case hardening** provides extra toughness for wear resistance, minimizes fatigue and retards corrosion.
- **Lubrication groove** in the crest of each thread (an I-R patent) retains lubricant and assures easy detachability.
- **Easier detachability**— IR38 thread form has a steeper helix angle that requires less torque to break thread connections, saving time and extending steel life.
- **Longer thread life**— The thread also has more flank area and greater contact area between mating threads. This reduces thread deformation and wear, contributing to longer thread life between reconditionings.
- **Carset® button bits**— Advanced metallurgy provides the best combination of carbide wear and bit erosion, to maintain proper button exposure. Precision manufacture prevents stress concentrations.

Ingersoll-Rand Company
Rock Drill Division
Phillipsburg, NJ 08865

INGERSOLL-RAND
DRILLING EQUIPMENT

SECTION 8 – [illegible]

One : [illegible] mounted with [illegible] [illegible] complete with [illegible]

PRICE	:	$61,180.00
PLUS 10% SALES TAX	:	6,118.00
TOTAL	:	$67,298.00

One : Ingersoll-Rand P[illegible] portable air compressor.

PRICE	:	$35,109.00
PLUS 10% SALES TAX	:	3,510.90
TOTAL	:	$38,619.90

30' : [illegible] air hose.

PRICE	:	$3,163.00
PLUS 10% SALES TAX	:	316.30
TOTAL	:	$3,479.30

ADDITIONAL AIR LINE FITTINGS

1" : O/S galvanized air pipeline.

PRICE	:	$11.60/M
PLUS 10% SALES TAX	:	1.16
TOTAL	:	$12.76/M

1" : Pipe support (used one every 10M).

PRICE	:	$28.87/each
PLUS 10% SALES TAX	:	2.89
TOTAL	:	$31.76/each

1" : Sockets.

PRICE	:	$6.35/each
PLUS 10% SALES TAX	:	.64
TOTAL	:	$6.99/each

Ingersoll-Rand IR38 Spi-Ral® Steel System: Up to 4" (102-mm) holes

STRIKING BAR		COUPLING SYMBOL	38 mm DRILL STEEL			BUTTON BITS	
SYMBOL	DRIFTER MODEL		SYMBOL	LENGTH FT.	LENGTH M.	SYMBOL	BIT SIZE IN.
[illegible]	VL-120/140	C38SCB	E38SB10	10	[illegible]	2½B38S	2½
						3 B38S	3
[illegible]	F-170		E38SB12	12	[illegible]	3½B38S	3½
						4 B38S	4

- Full-length thread[illegible] — The steel is threaded over its full length. [illegible]
- [illegible]
- [illegible]
- [illegible]
- Easier [illegible] — [illegible]
- Longer thread life — [illegible]
- [illegible] button bits — [illegible]

Ingersoll-Rand Company
Rock Drill Division
Phillipsburg, NJ 08865

INGERSOLL-RAND
DRILLING EQUIPMENT

[illegible]

SECTION 8 : PRICING SCHEDULE

One : Ingersoll-Rand LM100 drill rig, complete with YD90 drifter drill.

PRICE	:	$63,188.00
PLUS 10% SALES TAX	:	6,318.80
TOTAL	:	$69,506.80

One : Ingersoll-Rand P375SD portable air compressor.

PRICE	:	$33,109.00
PLUS 10% SALES TAX	:	3,310.90
TOTAL	:	$36,419.90

50' : 2" diameter air hose.

PRICE	:	$1,163.00
PLUS 10% SALES TAX	:	116.30
TOTAL	:	$1,279.30

ADDITIONAL AIR LINE FITTINGS

2" : Dia galvanised air pipeline.

PRICE	:	$11.44/M
PLUS 10% SALES TAX	:	1.14
TOTAL	:	$12.58/M

2" : Mac unions (used one every 10M).

PRICE	:	$28.47/each
PLUS 10% SALES TAX	:	2.84
TOTAL	:	$31.31/each

2" : Sockets.

PRICE	:	$4.91/each
PLUS 10% SALES TAX	:	.49
TOTAL	:	$5.40/each

DRILLING ACCESSORIES

		COST	SALES TAX	TOTAL
One	: Shank End	$147.00	$14.70	$161.70
One	: Coupling	$42.00	$4.20	$46.20
One	: 10' Drill Rod	$210.00	$21.00	$231.00
One	: 2" dia Button Drill Bit	$151.00	$15.10	$165.10

DELIVERY : All items can be available ex Auckland within eight to ten weeks from receipt of your firm order.

DELIVERY POINT : Free into store Linton.

CONDITIONS OF SALE : As per form attached.

CONDITIONS OF SALE

Definition In the following General Conditions, reference to the 'Company' shall mean Ingersoll-Rand Division Schlage (N.Z.) Ltd.

Payment Unless otherwise stated, payment shall be net cash by the 20th of the month following date of despatch of goods.

Guarantee and Liability The Company warrants that the apparatus delivered herewith shall be of the kind and quality described herein but no other warranty or condition whether with respect to description quality merchantability or fitness for any particular purpose whether express or implied by statute or otherwise shall bind the Company. The Company will repair at its factory or replace without charge f.o.b. factory any part or parts within 90 days from the date upon which the apparatus is first used by the purchaser being a date not more than oneyear after the date of despatch shall be proved to have been defective when despatched, provided that the purchaser shall promptly notify the Company in writing of such despatch and promptly deliver the defective part or parts to the factory where made, delivery prepaid. No allowance will be granted for any repairs or alterations made by the purchaser without the Company's written consent. The Company reserves the right to make, at any time, such changes in detail of design, construction, arrangement, or equipment as shall in its judgment, constitute an improvement over former practice. Upon payment of an extra charge the Company will make tests for economy and performance. Because of varying conditions of installation and operation, all guarantees of performance are subject to a variation of 3%. Equipment and accessories furnished by third parties are guaranteed only to the extent of the original manufacturer's guarantee to the Company. In case of failure of the Company to fulfil any performance guarantee, it is agreed that the Company may remove and reclaim apparatus covered by this Contract at its own expense and discharge all liability by repayment to the purchaser of all sums received on account of the purchase price. The liability of the Company (except as to the warranty of title and on the liability respecting any performance guarantee) arising out of the manufacture or sale of said apparatus, or its use, whether on warranties or otherwise, shall not in any case exceed the cost of repairing or replacing defective parts as aforesaid, and, upon the expiration of the said one year, all such liability shall terminate. The Company shall not be held liable for any special, indirect or consequential damages arising out of this Contract or any breach thereof, or any defect in or failure or malfunction of the apparatus furnished hereunder, nor shall the Company be liable for any loss or damage of any kind whatsoever caused by *force majeure* or circumstances beyond its control.

Tax All prices are quoted exclusive of Sales Tax. In the event of any additions or alterations in Sales Tax and Government imposts being brought into force before delivery of the goods which the Company has to pay and/or collect, the prices mentioned herein shall be varied by the amount of such tax, impost or imposts and this condition shall be deemed a term of the contract of sale.

Prices All prices quoted for goods manufactured or procured by the Company are based on wages awards conditions and material costs as at the date of quotation and all prices quoted for overseas goods are based on current manufacturer's prices, freight rates, insurance, exchange rates and customs duties, as at the date of quotation. The Company reserves the right to adjust quoted prices to compensate for any alteration therein and any such adjustments will be to the purchaser's account.

Delivery Any period or date of despatch quoted is given and intended as an estimate only and the Company will not be liable for any loss or damage arising out of any delay in despatch howsoever caused.

Exclusion of other terms The above conditions shall apply to all quotations given and orders accepted by the Company to the exclusion of any other terms and conditions contained in any document submitted to the purchaser to the extent that such last mentioned terms or conditions are inconsistent therewith or with any rights of the Company expressed or implied by law. No modification hereof shall be binding upon the parties hereto or either of them unless such modification shall be in writing duly executed by the purchaser and approved by a Director or Secretary of the Company.