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BLAST CLEANING IN INFLAMMABLE ATMOSPHERES

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SUMMARY

Grit blast cleaning is accepted as the best method of preparing rusted steelwork for painting and this can easily be carried out on ships' hulls in drydocks. The grit blasting of areas of ships' decks is more difficult; it can cause considerable disruption of other maintenance operations and has to be carried out whatever weather conditions prevail. In view of this it is logical to consider whether grit blast cleaning can be regarded as part of the ships' maintenance programme that can be carried out at sea. However, it has been observed that sparks are generated during the grit blasting of rusted steel. We believed that it was essential to know whether these sparks could ignite inflammable liquids or gases of the type that could be present on the deck of a laden tanker before grit blasting trials could be attempted on board a ship.

Tests have been carried out to study the ignition capability of sparks produced by grit blasting. The sparks produced were numerous but dull and on no occasion did they ignite an inflammable gas mixture. A brief literature review indicates that other workers have reported similar findings.

Following this work a full-scale grit blasting trial was carried out at sea on a lubricating oil carrier. Details of this work and the safety procedures followed are given. It is concluded that grit blasting can be employed successfully on board vessels while they are at sea provided that all normal safety precautions, and the additional ones given in this paper, are adhered to.

BLAST CLEANING IN INFLAMMABLE ATMOSPHERES

INTRODUCTION

Grit blast cleaning of rusted steelwork to remove all traces of paint, rust and corrosive salt contaminants is now accepted as the best method for steel preparation prior to recoating with protective systems. Experience has shown that it is now possible to clean even the most severely corroded steel surfaces to very high standards.

Grit blasting of the outer hull of a ship is a comparatively easy operation in drydock and, provided local regulations permit, can take place at most times during the drydocking without undue interference with other activities. However, the grit blasting of the deck area, pipework and flying bridge is difficult. In order to isolate these areas for grit blast cleaning considerable disruption of other maintenance operations is involved. Thus, before deck maintenance can be carried out in a drydock most other work has to be completed. If this work has to be completed in a drydock, then the docking period has to be extended by several days and this can be very costly. A further complication is that the whole cleaning operation must be carried out in whatever weather conditions prevail at the time. Faced with these difficulties it was logical to consider whether grit blast cleaning could be regarded as part of the maintenance programme that could be carried out at sea.

It has been observed, during grit blasting at night, that streams of sparks are generated by the abrasive particles impinging onto the rusted steel surfaces. Before any blast cleaning was attempted at sea we thought that it was essential to know whether the sparks produced during grit blasting could ignite inflammable liquids or gases of the type that could be present on the deck of a laden tanker. On tankers, especially around the hatches and vents, the gases given off by crude oils or products can, under certain conditions, be within the explosive limits for gas/air mixture.

EXPERIMENTAL

Design of test rig

To study the ignition capability of the sparks produced by grit blasting, a test chamber, 750 mm diameter and 1000 mm high, was constructed from 9.5 mm mild steel plate. The chamber was closed at the top, open at the bottom, and mounted on a 600 mm high stand. This was to allow the grit blasting air and gas mixture to escape and to prevent a build up of abrasive within the chamber. A Hodge Clemco 14-40 "Shipblaster" grit blasting pot fitted with a 9.5 mm diameter nozzle was used for the tests. This unit is designed for use on board ships and is slightly smaller than the one favoured by contractors for land-based grit blasting. The blasting nozzle could be clamped in such a way that the distance between the test plate and the nozzle could be varied. The test plate was fixed into position in the top of the chamber at an angle of 45° to the grit blasting stream. In preliminary tests, with a blasting air pressure of 7 bar, sparks could be produced by the grit hitting a rusty steel plate even when the nozzle was up to two metres away from the plate. (A, B and C, Plate I.) A gas inlet pipe was fitted into the chamber top near to the test plate in such a way that the stream of gas was directed into the part of the chamber in which the sparks would be produced. An automotive sparking plug, coupled externally to a coil and battery, was fitted into the top of the tank.

This was used to produce sparks that could ignite the atmosphere within the chamber and so check that explosive conditions existed within it. A sketch of the test chamber is given in Figure 1.

An examination of the ullage space gas (Table 1) present in a tanker carrying Middle East crude oil indicated that it had an explosive range very similar to that of propane and as propane is readily available we decided to use this gas in all our experiments.

Table 1

Comparison of the properties of propane and ullage space vapour

	Propane	Ullage space gas from a typical Middle East crude oil
Low inflammable limit, % volume in air	2.2	2.25
Upper inflammable limit, % volume in air	9.5	9.71
Vapour density (air = 1.0)	1.55	1.59

The propane gas had to be supplied to the chamber at rates of up to 30 litres/min. To obtain this, liquid propane was fed through a heat exchanger and was monitored as it passed into the chamber through a control valve and rotameter (Figure 2).

Test explosions were induced using different air/grit/gas mixtures fired by the sparking plug. In this way the optimum conditions for maximum detonation (i.e. approximating to stoicheiometric proportions) were establishec Although it is possible to predict the explosive limits, and to measure the gas flow accurately, it is not easy to measure the air flow through a blasting nozzle with any degree of accuracy. The reason for this is that although the air flow through the nozzle can be calculated if the pressure and nozzle diameter are known, the reduction in air volume resulting from the bulk volume of the entrained abrasive cannot be established easily. The air flow/grit ratio was kept as constant as possible throughout the experiments and was set for maximum grit blasting efficiency.

Abrasives

Two copper slag abrasives, representing a coarse and a fine grade, and an S170 steel shot abrasive were used in the tests.

Test procedure and results

The blasting nozzle was fitted into the chamber in the desired position and the blast air was turned on while the grit valve remained closed. Propane gas was then introduced into the chamber and a test firing made using the sparking plug. The gas flow was gradually increased until detonations of what appeared to be maximum violence occured. Abrasive was then introduced into the blast stream to the required amount and the gas flow was adjusted to compensate for the volume of grit until explosions of similar intensity were obtained. When the experimental conditions had been established the tests were commenced and continued for several hours until either the grit or the propane gas was exhausted. Firings with the spark plug were made at regular intervals throughout, and at the end of each experiment, to ensure that explosive conditions prevailed throughout.

In addition to the tests carried out with the blasting nozzle at 45° to the steel plate some were carried out with the blasting nozzle and the gas inlet in various positions; these included fitting a sleeve around the blasting nozzle and introducing the gas at that point. The tests lasted for several hours and were carried out in a variety of atmospheric conditions (still and moving air, dry and warm, cool and wet).

The atmosphere in the vicinity of the chamber contained so much gas that normal manual blasting would have been impossible without the operator wearing breathing apparatus. During each test firing the flame front spread for several metres around the chamber, (Plate II).

The sparks produced by the grit streams were numerous but dull and they could only be observed in darkness. On no occasion did they ignite the inflammable gas mixture present in the test chamber. We believe that this could be because the sparks are of low energy and it is possible that they are cooled by the surrounding air before it reaches the explosive range.

DISCUSSION OF TEST RESULTS

Casdorph[1] has reported similar findings (i.e. no ignitions occurred) when he carried out tests in the USA using sand blasting equipment. He examined the problems of sand blasting in chemical plant in the presence of a range of inflammable materials, including acetaldehyde, kerosine and gasoline. Some of the physical properties of these materials are given in Table 2.

His tests were carried out using an iron table with a steel backing plate. The blasting jet was directed onto a test plate at various angles. Inflammable test liquids were fed under pressure into the jet stream as well as onto the table top and backing plate.

Further tests were reported in which the table and backplate were wetted with the test liquid and ignited (in the case of kerosine the table

Table 2

Properties of materials used in the tests reported by Casdorph

	Flash point °C	Ignition temp °C	Boiling point °C	LEL (lower explosive limit), %v	UEL (upper explosive limit), %v
Acetaldehyde	-38	140	21	4.1	55.0
Kerosine	38-74*	227	210-260	1.16	6.0
Gasoline	-43	240-400	40-200	1.3	6.0

* Closed cup.

and backplate were preheated to facilitate evaporation). Further fuel was pumped into the area to feed the fire. The sand blasting was then started and in each case the fire was extinguished and no re-ignition occurred even though the liquids were still evaporating or boiling. Bradley[2] reported further tests in which a 2 ft length of 26 inch diameter pipe was welded to a 3 ft x 4 ft x 3/16 inch plate. Two pipes were fitted into this tank, one for the introduction of gasoline and the other as a take off sampling pipe which led to an explosimeter test instrument. Test firings were made using sparks produced from a remotely operated welders' friction lighter. Gasoline was fed into this tank and the gas/air mixture in the tank was monitored, using the explosionmeter, while the sandblasting jet impinged on the bottom plate inside the tank. His tests covered the whole range from the over-rich down to lean gasoline/air mixtures and no ignitions associated with the sandblasting occurred during any of them.

All these tests support the view that sparks produced during abrasive blasting operations using air as the propellant are incapable of causing explosions in inflammable atmospheres. However, there is the possibility that sparks could be generated by static build-up during the blasting operation and these could constitute a hazard.

Bradley has reported static build-up test results. In these tests a steel strip, 3 inch x 9 inch, was sand blasted while being insulated from earth by a wooden post. A voltage in excess of 16 kV built up on the steel strip. A spark produced by this voltage would be expected to ignite an inflammable gas/air mixture. When the same strip was properly earthed no voltage build-up occurred.

The tests described previously, together with the work of other investigators, indicated that grit blasting could be carried out without hazard, in inflammable atmospheres provided normal safety precautions were observed and knowing this we decided to carry out grit blasting trials at sea. It was decided that the initial work should be carried out on a low-fire-hazard lubricating-oil carrier.

Deck grit blasting trials at sea

A Hodge Clemco 1452 grit blasting pot, a 265 cfm compressor, a Jet-Vac industrial vacuum cleaner and a CA100 airless spray unit, together with all auxiliary hoses and equipment, were loaded on board an 18 000 ton, 12 year old tanker. The compressor was installed in a "safe" area on the poop deck and was supplied with sufficient hose to enable blasting to take place on any area of the deck. It was essential that all the hoses and pipework to be used were of the antistatic type. All the blasing and painting was carried out by the ships crew members after an initial one day training session at the beginning of the voyage. The author acted as an observer throughout the trial. During the grit blasting operations it was decided that in addition to all normal fire regulations and precautions being observed, any points where gas or liquid leaks might occur, i.e. vents, sampling points, sight gauge apertures, should be adequately blanked off; this precaution also prevented the ingress of abrasive into those areas. The structure being cleaned, compressor, blasting pot, nozzle and the operators were all electrically bonded together.

The port area of the foredeck immediately forward of the centre castle was chosen for the initial trial and blasting commenced as soon as practicable once at sea. After blasting for several hours the bulk of the spent grit was removed by brush and shovel and the residue was blown off with an air jet. This proved to be the most satisfactory method in the open areas of the deck. The Jet-Vac industrial vacuum cleaner was found to be the most efficient way of removing the grit from the cluttered spaces around decklines and valves. After removal of spent grit and dust the area was primed using airless spray equipment. In the first two days of the trial approximately 110 square yards (90 m^2) were completed; this included all above-deck projections, e.g. tank lids, valve casings, sighting ports, ullage plugs, deck lines and a ladder (E, F and G, Plate III). Most areas were consistently blasted to an Sa $2\frac{1}{2}$ standard and only occasionally, in difficult or heavily scaled areas, did the standard of surface preparation fall to Sa 2.

As areas were cleaned the blasting operation was transferred to different sections in order that the painting could be carried out without grit particles getting onto the freshly painted area. The most difficult areas to clean were the flying bridge and supports and the associated piping of the loading and discharge manifold because of their closeness and inaccessibility. (H and I, Plate IV). The flying bridge supports and pipes were in poor condition, coated with heavy rust and scale which had resulted from years of neglect, because the awkwardness and clutter of the area had made maintenance by conventional methods almost impossible. The flying bridge was roped off and the grills were removed to give access to the upper surfaces of the pipes and the angles of the flying bridge supports. The blasting programme was carried through as a continuous exercise for six days, each area cleaned receiving a primer coat after each days blasting.

During all of this work J Blast Supa abrasive was used and was found to remove adequately even the thick tenacious scale present on the deck steam lines. On the dry decks much of the grit was recoverable and was re-used after sieving through a 3 mm sieve. This used abrasive was mixed with new grit in the pot in the ratio of three bags of new grit to two bags of reclaimed abrasive. The total consumption of new abrasive for 350 square yards (293 m^2) of cleared steel was 210 cwt (10 668 kg) and at the end of the trial approximately 80 cwt (4064 kg) reclaimed grit remained. Throughout the trial the 265 cfm compressor produced nozzle pressures in excess of 80 lb/square inch (5.7 bar).

CONCLUSIONS

The experiments carried out in Thornton Research Centre and by other workers showed that grit blast cleaning of rusty steel could be conducted in inflammable atmospheres. Additionally, we have now shown that grit blasting can be carried out successfully on board a vessel at sea. While the trial described was carried out on a relatively safe ship, a lubricating-oil carrier with a low fire risk, we believe that there are no reasons why grit blast cleaning cannot be carried out with safety on board oil tankers in inflammable atmospheres provided that all normal safety precautions and the additional ones given in this paper are adhered to.

It should be stressed that the author was concerned only with the transportation of petroleum crude and products. The nature of other possible hazards should be ascertained before any blasting is attempted in atmospheres other than those dealt with here.

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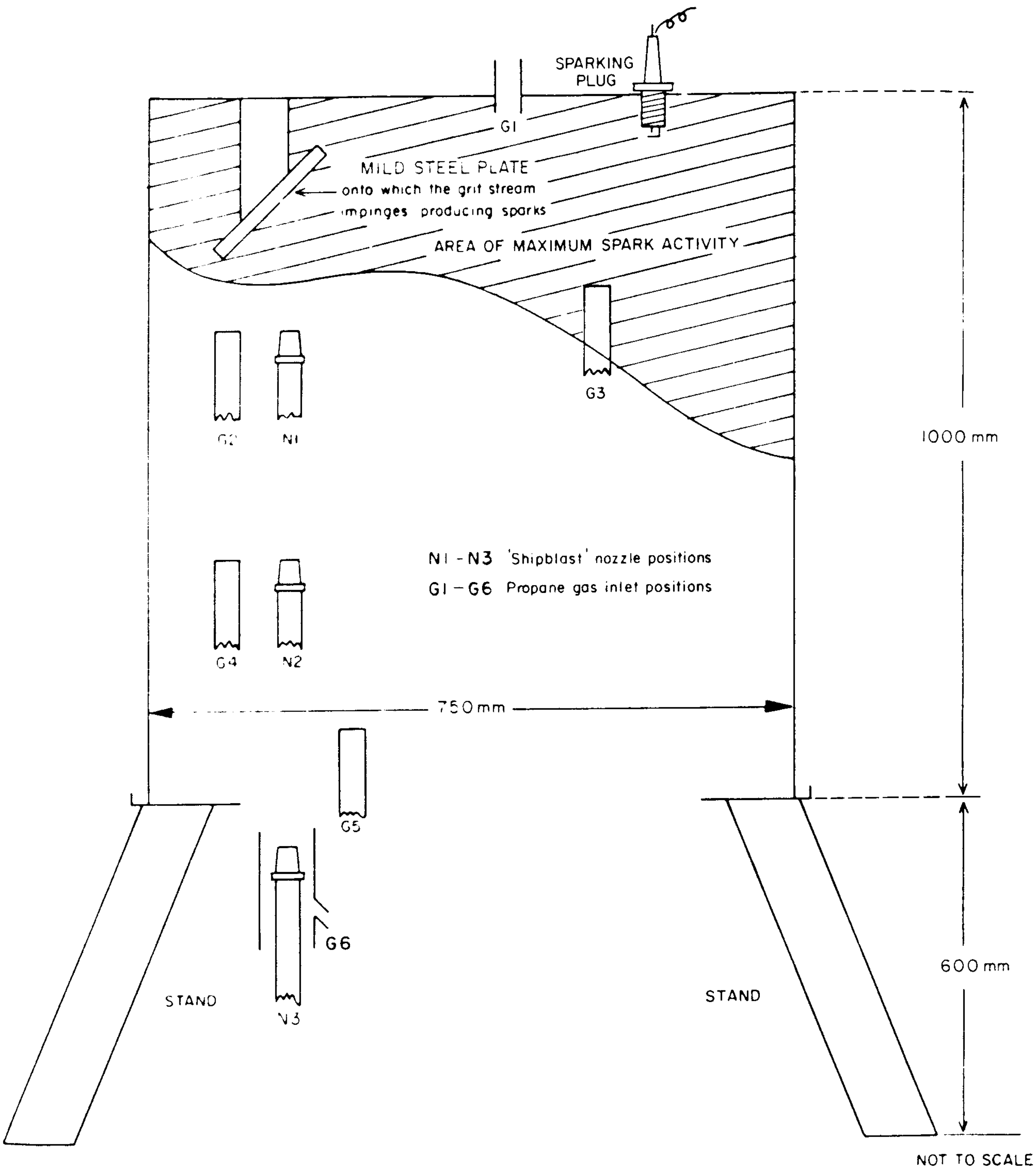


FIG 1 – Sketch of cross section of blast chamber showing nozzle positions (N) and gas inlet positions (G)

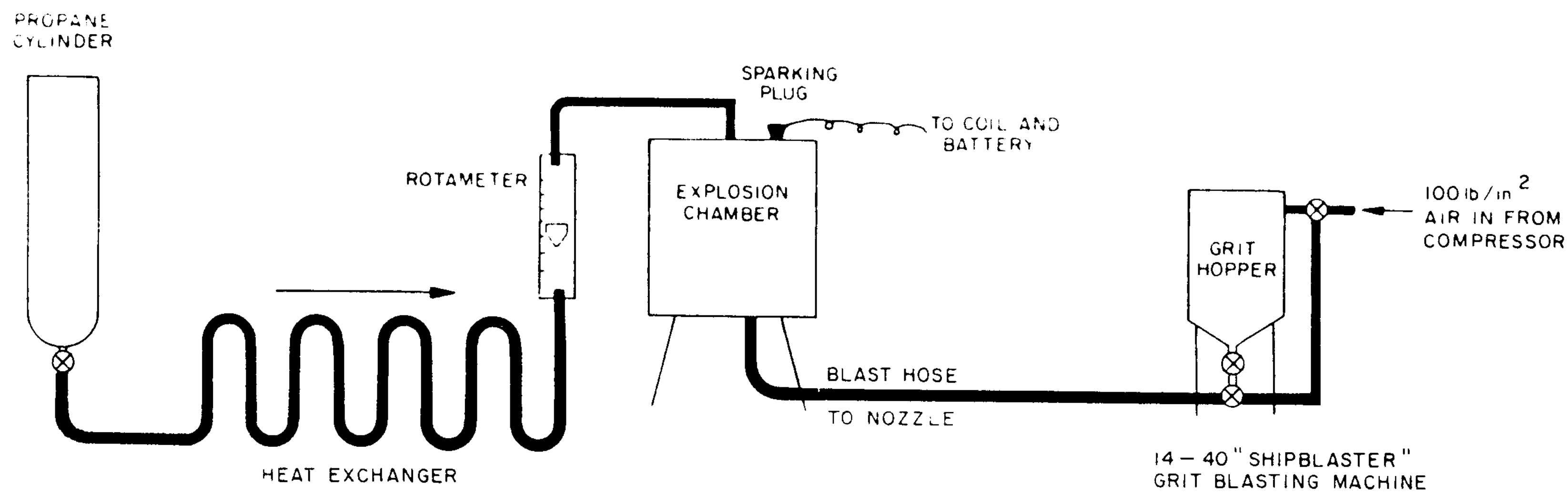


FIG 2 —Diagram of explosion rig

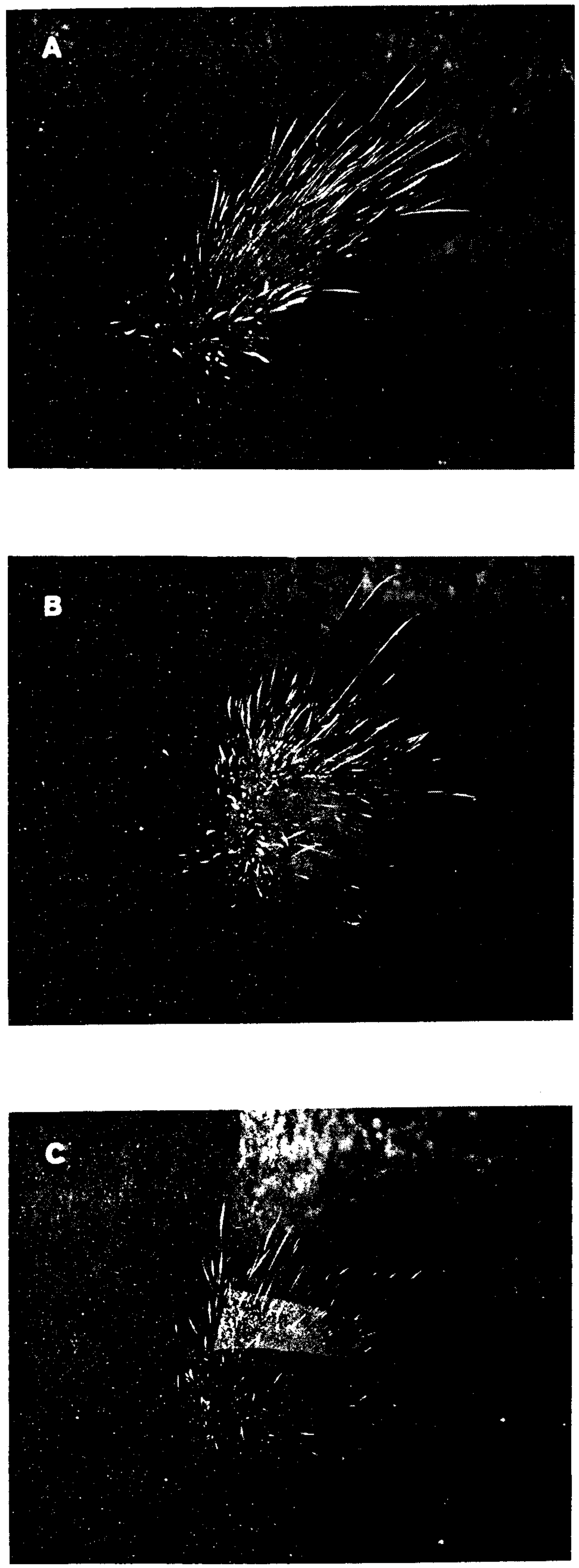
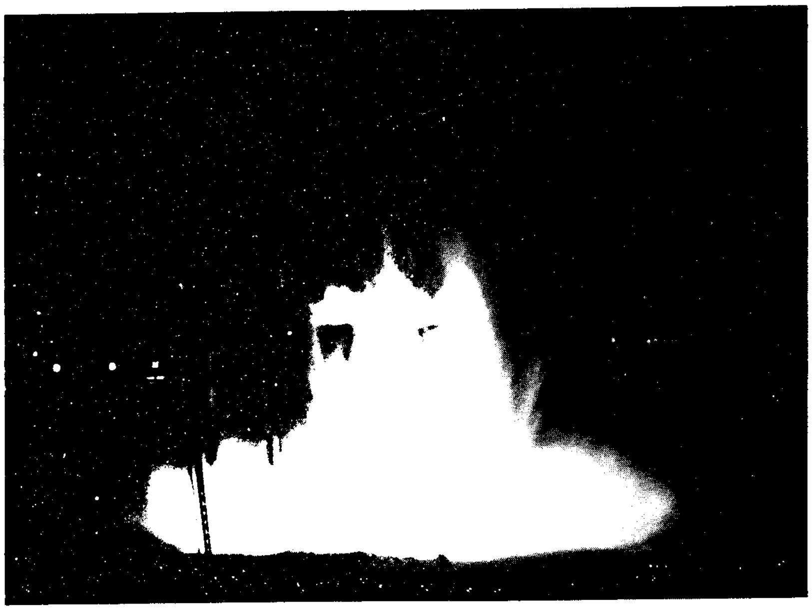
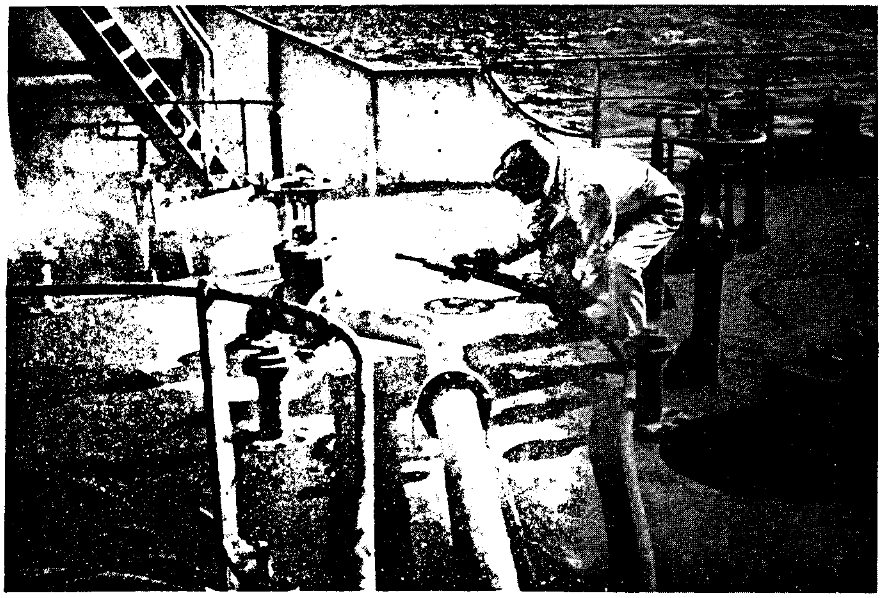


PLATE I — Sparks produced by grit blasting – nozzle angled at 45°
to the test plate. A at 0.6 m, B at 1.3 m, C at 2m

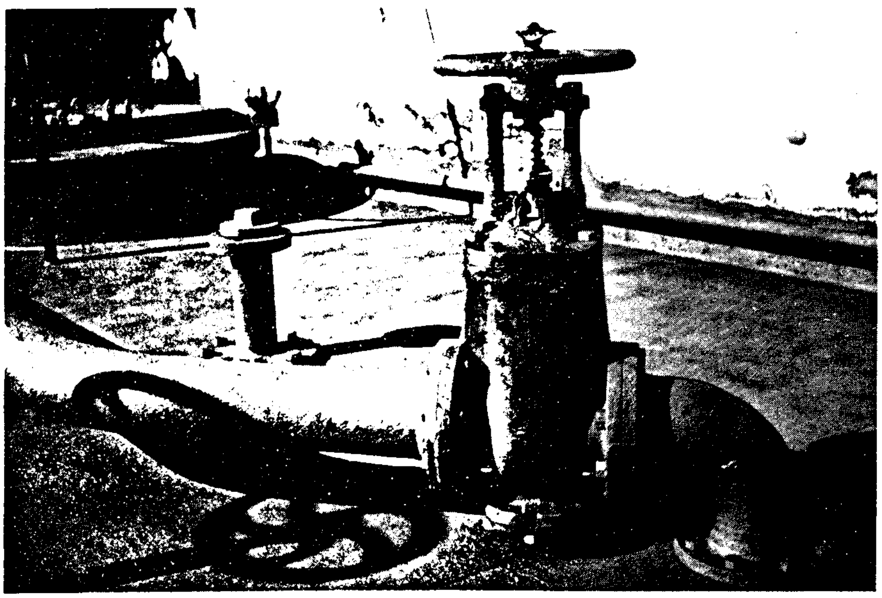


D Flame front produced during a test firing

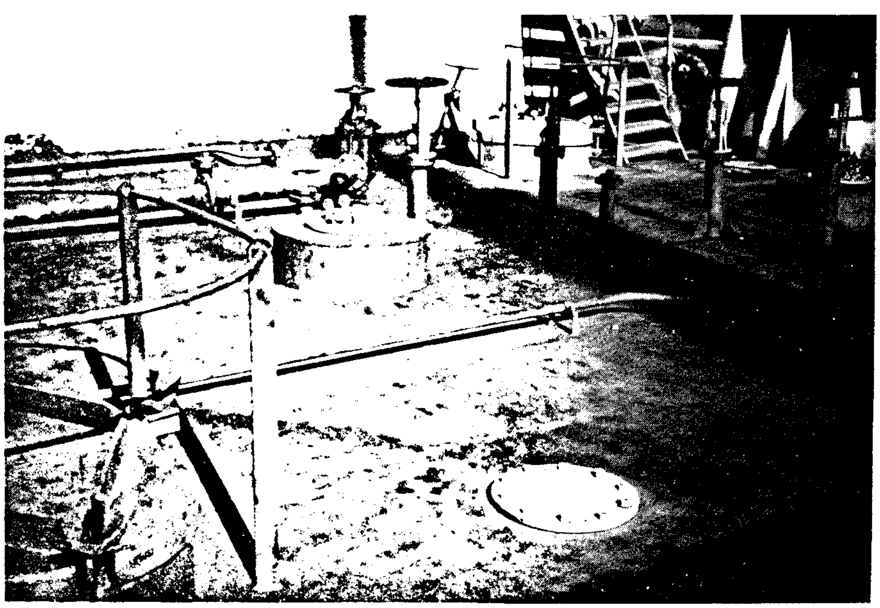
PLATE II



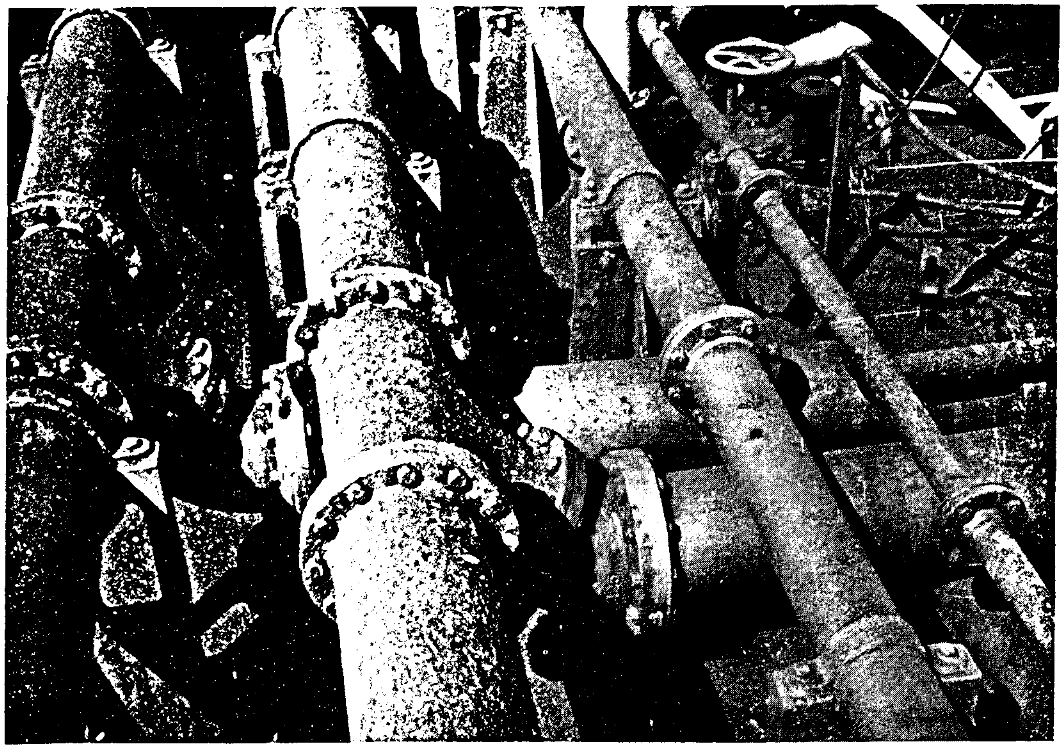
E. Grit blasting in progress on foredeck during a sea voyage



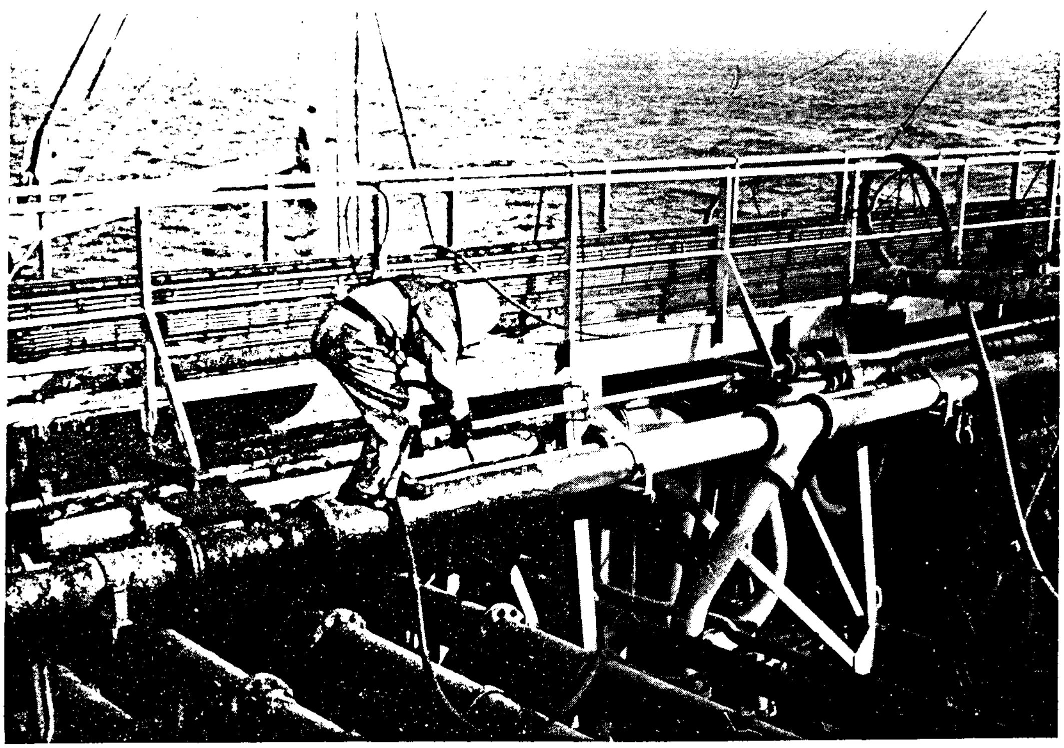
F. Deck valve showing the effectiveness of the grit blasting — Note deep corrosion pitting in the valve casing



G. Area of foredeck after grit blasting



H Pipework in the manifold area illustrating the difficulties facing maintenance teams



I. Blasting pipework alongside the flying bridge during a sea voyage

PLATE IV — Manifold areas