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DEVELOPMENT OF MULTI-USE SHIPBOARD INCINERATOR. MFI REFURBISHME--ETC(U)
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(6) DEVELOPMENT OF MULTI-USE SHIPBOARD INCINERATOR. [redacted], MFI Refurbishment Program.

NAVSEA CONTRACT NO. (15) N00024-75-C-4199

PHASE II
MFI REFURBISHMENT PROGRAM
FINAL REPORT

March 20, 1978

APPROVED FOR PUBLIC RELEASE-DISTRIBUTION UNLIMITED

MFI REFURBISHMENT

FINAL REPORT

1.0 Background

Formal testing of the original Phase II unit was discontinued in March, 1977.

The unit was considered unsuitable because of refractory shock and vibration damage experienced in shipment.

VOM proposed to redesign the firebox module shell in accordance with shock and vibration MILSPECS as analyzed by Littleton Research.

Design parameters were resolved in April, 1977 as detailed in VOM Report No. 210.

Drawings were completed in May, 1977 and fabrication commenced at NSWC, Dahlgren, Virginia in June, 1977.

The unit was released to NAVSEC and NSWC for test on March 9, 1978.

All details of Refurbishment are covered in VOM Report Nos. 210-236.

2.0 Design Problems and Resolutions

2.1 Refractory Cracking and Displacement

Vulnerability to shock cracking was considered to be due to insufficient support of the shell-anchor system. It was felt that the original 3/16" diameter V-type anchors welded to 10 ga sheet metal was not adequately rigid under high shock loads.

Littleton Research calculated that 3/16" thick vertical shell panels and a 3/8" thick top panel would satisfy MILSPECS (Report No. 210). When used in conjuntion with 5/16" diameter, deformed V-type anchors.

VOM increased vertical panel thickness to 1/4" and specified all welds to be continuous full penetration.

Original sewage nozzle inlet and flame port configurations were changed from rectangular to oval to limit corner cracking vulnerability.

2.2 Feeder Panel Shell Warpage and Weld Cracking

Excessive shell panel warpage had been experienced when the feed door was raised due to the close proximity of the hot door refractory. Shell deformation strains caused weld cracking on firebox opening structural members.

The new design displaces door face an additional inch from the shell and reinforces the exposed upper panel with a builtup box section; in addition to increasing shell thickness from 10 ga to 1/4". Further improvements are: opening framing changed from flat bar to structural channel, welding full penetration continuous, reduced exposed framing metal, and increased insulation of refractory protecting the front panel.

The feed door was also modified to effect air cooling through hose connection to jacket suction.

2.3 Sewage Chamber Refractory

Original side entry sewage nozzle configuration necessitated use of fragile insulating billet. New rear nozzle entry design minimizes penetration size and obviates need for spray assembly insulation.

Original spray impact wall of Greencast 97 showed signs of spalling. Changed material to Jade-Pac 88 plastic and added similar nozzle block.

2.4 Jacket Temperature Reduction

Prolonged sewage burning at 1900°F firebox had resulted in some jacket areas in excess of 140°F. Redesigned shell flanges are now turned inward so as not to obstruct cooling air passages. Jacket insulation was increased from 1/8" paper to 1/4" foil-backed felt.

3.0 Fabrication

3.1 Metalwork

A few problems were experienced because of plate warpage and cold flanging inaccuracies with the 1/4" plate used. Cold flanging proved especially critical after refractory casting, since mechanical springing of metalwork to effect final assembly produced relatively minor refractory cracks. As a precaution, several panels were recast. This effect is much more pronounced when using 1/4" plate and stiff anchors than the more pliable 10 ga with relatively flexible anchors used originally.

Flawless cold forming of 1/4" plate flanges of the desired dimensions proved more difficult than one would normally anticipate. The narrow flanges (1¼") required small inner radii and extreme care in edge preparation.

Despite the experiences described, the metalwork produced at NSWC was of very good quality. All welds and cold-formed flanges were proven sound by Magnaflux inspection.

The basic design appears sound. For the subsequent design some minor dimensional changes are required plus care in selection of material, and fixturing more appropriate to multi-unit production.

3.2 Casting

Casting operations, as detailed on VOM-4199-2-750-D, were expeditiously conducted without problems. Minor exceptions to plans were: use of Sairset as interface seal and substitution of Beeswax for Paraffin (not adhesive enough) on anchor coating.

Found Jade-Pac 88 very difficult to work in large quantities and curing to 700°F inconvenient and time-consuming.

All castings were allowed to set for 48 hours under plastic cover before moving.

3.3 Assembly

While minor difficulties were experienced due to the aforementioned warped panels, the most salient feature of this phase was the need for heavy handling equipment, special slings and lots of space. The MFI was transported fully assembled to the test site by flat bed trailer. No cracks were evident on arrival.

Serious consideration of on-site assembly in small compartments may necessitate lighter weight refractory or further sub-division of components.

3.4 Refractory Curing

The MFI and two additional test tops were cured according to A. P. Green's recommended schedule. Further precautions were taken by extending critical hold points several hours beyond that recommended. Some ambiguity remains, however, because of the wide temperature gradient through the unit. It was found, for example, that in order to attain 1800°F on the back side of the sewage chamber, it was necessary to maintain 2500°F in the firebox. It thus was impossible to cure the Jade-Pac 88 to the recommended 2200°F to set phosphate bonds. Subsequent consultation with the manufacturer confirmed that little Jade-Pac capacity would be lost by curing to 1800°F. Late in the cure period at 2500°F a 35 minute emergency shutdown due to operator error occurred during which time the inner shell may have reached 600-800°F. Shell expansion at this temperature which would severely strain the refractory, may account for some of the cracks subsequently observed.

Two test tops, cured separately from the MFI, were found to be similarly cracked as the unit top. All three were humped up in the middle with cracks radiating from the center even though three different anchor systems were used. It appears that neither bolted or welded A. P. Green anchors nor S-type NAVSEC anchors are solely responsible for the cracking phenomenon.

As in all dense refractory linings shell thermal cycling strains are the major source of cracks. Careful curing and minimizing of thermal cycling will help to assure structural integrity of the lining. Report No. 229 details curing difficulties.

4.0 Auxiliary Systems Refurbishment

4.1 Feeder Controls

Replaced "time window" with "add-subtract" feeder control system in December, 1977. Hardware works well with operator resetting the timer for varying charge compositions. Ultimate use in conjunction with hopper or grate load sensing system may be considered (but see Para. 6.2 below).

4.2 Induced Draft System

Loss of power while curing apparently caused overheating of the stationary I.D. fan shaft. A wheel end shaft set caused unbalance which contributed to premature bearing failure. The entire rotor assembly was replaced.

A longer term solution may be an automatic damper bypass around the fan to be used under uncontrolled heating conditions. Long-term testing should provide an indication whether this modification is necessary.

4.3 Sewage System

The sewage nozzle assembly was extended 4" with an intermediate nipple section so as to eliminate refractory wetting around the nozzle inlet port. The spacer is to be replaced with a Hastalloy equivalent when available.

4.4 Feed Door Cylinder

Neoprene piston seals were replaced in the feed door cylinder. Damage was the result of abnormal overheating at an indeterminate time.

4.5 Feed Hopper

Curing heat apparently warped the feed chute nose causing interference with the feed door. Jacked the nose apart to provide 1/4" clearance.

5.0 Shake Down Test Results

5.1 Solid Waste Reduction

Ample excess capacity was evident throughout the tests. On several occasions over 200 lbs/hr was charged and burned without difficulty.

The high incidence of metal and glass (12-15%) in trash presented no difficulty in spite of failure of the latter to be automatically discharged into the ash drawers (too heavy). Next-day cleanout can be accomplished in less than 5 minutes.

Computer scroll packets and unusually wet garbage require stoking and/or levelling for less than 1 minute per hour to insure complete burnout.

The feeder system worked well with little evidence of hopper fires noted in the past.

The feed door cooling mod greatly reduced problems due to melting plastic.

5.2 Sewage Burning

Approximately 40 hrs of sewage burn operation has produced no visible evidence of deterioration either on refractory or in the delivery system. No incidence of nozzle plugging was observed nor has any odor been apparent. The spray is consistent, well-dispersed and rapidly vaporized with no evidence of liquid accumulating on refractory. Burn rates were slightly above 40 gph.

5.3 Waste Oil Burning

Except for minor water segregation in external piping, and dirty mixing tanks the MFI burned waste oil flawlessly for over 30 hours without flameouts. Switchover problems have been resolved by manually purging supply lines. This function could easily be done automatically by continuous recirculation from the pumping unit inlet to the tank.

5.4 Smoke Reduction

When the firing rate of the burner is set for maximum output and sewage burn calls for maximum firebox temperature, charging of very volatile material was observed to produce intermittent puffs of black smoke as the burner ignites. This problem was remedied by reducing burner output at hi-fire and delaying burner ignition for two minutes after a charge.

6.0 Preliminary Assessment of Refurbishment Modifications

6.1 Shell Design

Significant improvement in durability of refractory around the feeder front panel, sewage nozzle inlet, hatch and flame port and ash door overhead is attributable to metalwork redesign.

The larger panels should be stiffened further. Bolted anchors, loosely assembled with double jam nuts and larger clearance holes should be used for maximum independence from shell strains.

Reduction in shell temperature cycling range under normal and emergency conditions by adding insulating refractory, providing more cooling air, adding heat sinks, etc. should reduce cracking vulnerability.

Jade-Pac 88 appears much superior to Greencast 97 for sewage chamber use.

6.2 Feeder Controls

Feeder electric controls may have grown too complex to the detriment of reliability, maintainability and fault location.

Existing hardware presently accounts for half the required panel space and consists of: 6 relays with 13 contacts, 7 switches with 15 contact blocks, 2 timers with 8 contacts, 2 counters, 8 limit switches, 4 solenoid valves and 8 lights.

Weighing the desire for automation against the lack of attention normally accorded an incinerator, a trade-off has to be made between convenience and reliability. The present extended test program is expected to provide some guidance.

The need for automatic feed controls to prevent over-feeding is an area which should be reviewed in this light. The consequences of over-feeding are not particularly serious and probably would be experienced from time to time regardless of the sophistication of control equipment. At worst, firebox compaction might prevent clearing a charge, leaving an ignited partial load burning in the hopper.

A simple water spray extinguishing system would seem to address the problem more directly than complex controls and may indeed be prudent in any case.

It is felt that in the long run the best load sensing instrument is a pair of human eyes; given adequate visible access to the firebox charge.

Accepting the above premises, a strong case can be made for eliminating most electrics pertaining to feeder control in favor of direct manual operation. Two small spring centered, lever operated, feeder mounted, 4-way air valves would satisfy convenience, fail-safe requirements.

6.3 Jacket Temperature Reduction

Refurbishment mods have been effective in maintaining the jacket proper at acceptably low temperatures. Penetrations are exceptions, but each is to be fitted with a guard to prevent contact.