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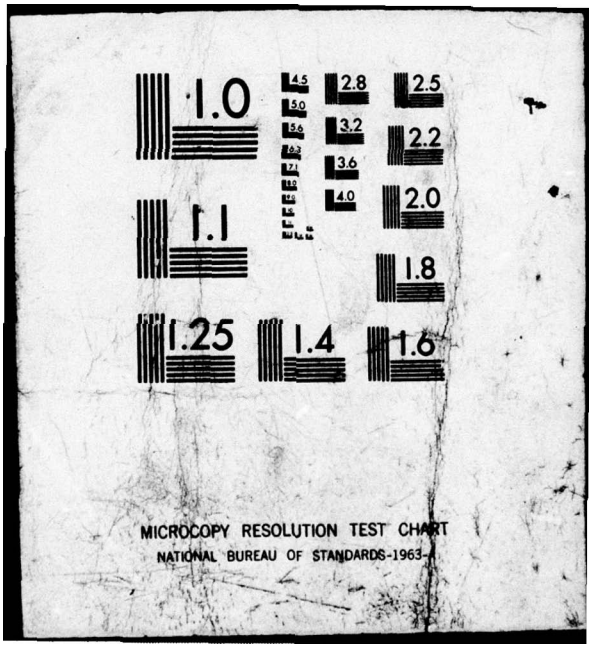
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INVESTIGATION OF A LIQUID OXYGEN SAMPLER CYLINDER EXPLOSION

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10 DECEMBER 1976

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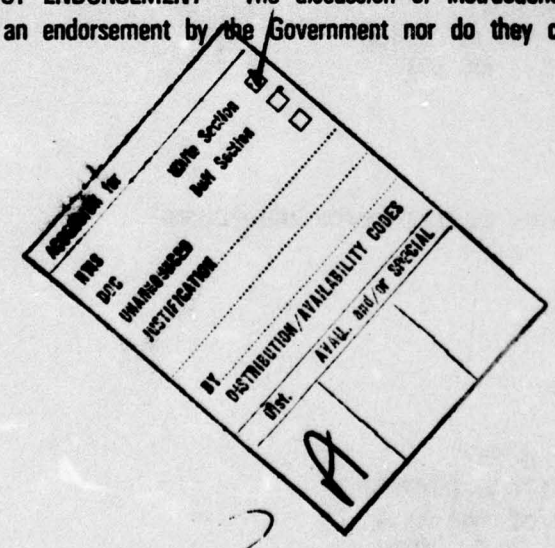

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Liquid Oxygen

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An explosion occurred because an improper silver solder joint permitted a separation to take place between the nipple and the stainless steel tube which allowed an excess volume of LOX to accumulate in the cylinder, thus an excess pressure built up. The presence of a fusible alloy behind the safety disc prevented the disc from bursting.

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INTRODUCTION

Two Navy G-276 liquid oxygen samplers, charged with LOX from a Naval Air Facility, Warminster storage tank, were delivered to the Aero Materials Laboratory for routine laboratory analysis. One of the samplers exploded in the laboratory causing extensive property damage, but only minor injury to personnel. An investigation was conducted to determine the probable cause of the explosion.

DISCUSSION

It was noted by laboratory personnel at the time of delivery that one sampler cylinder was completely covered with frost whereas the other sampler was frost-free. While test preparations were underway a steel retaining band on the frosted cylinder cracked and fell to the floor. Approximately five minutes later the frost-covered cylinder exploded. Figures 1, 2, 3 and 4 show some of the extensive physical damage caused by the explosion. A laboratory technician who was standing in the location shown in Figure 1 sustained minor cuts and a temporary loss of hearing. Three major sections of the exploded cylinder came to rest in the locations shown in Figures 2 and 3. Figure 4 shows a typical G-276 LOX sampler cylinder in a stand near an area of the damaged wall in the hallway and some of the shattered steel bands. Figure 5 shows the various parts of the exploded cylinder. It appears that the valve, nipple and sampler filler tube, upon separation from the exploding cylinder, were propelled upward to the ceiling, causing some damage and finally landing on the floor about four feet apart. The wire bands were scattered throughout the area as shown in Figures 1, 2, 3 and 4.

FAILURE ANALYSIS OF THE CYLINDER

Detailed photos of the tube, nipple and exploded cylinder are shown in Figure 6. Close examination of photos 1, 2 and 3 (Figure 6) show that many areas along the circumference of the tube and nipple were void of silver solder (see arrows). Specifications of the nipple assembly from the Naval Air Station, Alameda, California, O&R Department Drawing 212258 of 5 December 1958 (Figure 7) show that the stainless steel tube should have been recessed into a 0.26" (0.66 cm) counterbore. The SS tube from the exploded sampler was found to be counterbored less than 0.062" (0.158 cm), practically forming a butt weld with very little filler metal. It is believed that a crack between the tube and nipple existed prior to the last sample charge. This separation permitted an excess volume of LOX to overflow into the cylinder during the filling of the sampler tube. The discoloration of the inside of the cylinder as shown in Figure 5 (arrow) shows that liquid was present in the lower portion of the cylinder. Photo 4 (Figure 6) shows some damage to the threads of the nipple adaptor. The slight damage to the nipple threads and also to the cylinder threads (not shown) indicates the separation of the adaptor assembly and cylinder occurred simultaneously with the rupture of the cylinder walls. Photos 5 and 6 show cracks (open arrows) in the interior surface below the threads in the neck of the

cylinder. These cracks are visible without the aid of any magnification. The maximum depth of the cracks found three-fourths of an inch from the ANPT thread was 0.015" (0.038 cm). The minimum wall thickness at this point was 0.343" (0.871 cm), or a crack depth of 4.5% of the wall thickness. Cracking was detected to a distance of 1-3/4" (4.445 cm) from the ANPT thread. At this point the crack penetrated to a maximum depth of 0.0075" (0.019 cm) where the wall thickness was 0.156" (0.396 cm), or a crack depth of 5% of the wall thickness. *Photo 7 shows the pressure relief assembly nuts which are extensively used on* the Navy G-276 sampler exit valves. These nuts have access ports which can be filled with fusible metal alloy which will melt when excess temperatures occur, allowing the safety rupture disc to release the excess pressure. The nut on the left has a fusible metal alloy behind the safety burst disc. The pressure relief nut on the right shows no fusible metal alloy in the access ports. Since all Navy G-276 LOX samplers are designed for low temperature use, the presence of the fusible metal alloy would prevent the escape of excess LOX pressure. Therefore, all Navy G-276 sampler valves should have a safety relief nut without the fusible alloy. The safety relief nut on the valve of the exploded cylinder still had the fusible metal alloy behind the safety disc.

Infrared spectrophotometric analysis of the oxygen sample in the undamaged G-276 sampler charged from the same source at the same time as the malfunctioned sampler showed satisfactory quality of breathing oxygen with no evidence of abnormal or excess contaminant levels.

CONCLUSIONS

Based on the evidence available, it is believed that the explosion occurred because a separation between the nipple and the stainless steel sampler tube allowed leakage of LOX beyond the filler tube. The excess volume of LOX which accumulated in the bottom of the cylinder produced a gas pressure buildup which exceeded the bursting strength of the cylinder. The use of an unbacked safety disc on the vent valve assembly would have permitted the pressurized gas to escape.

RECOMMENDATIONS

Appendix A gives a detailed inspection procedure for G-276 Liquid Oxygen Sampler Cylinders. It is recommended that this inspection procedure be followed.

A C K N O W L E D G E M E N T S

The assistance of Mr. A. Shanks of the Photo Department, Mr. M. Perlman, the Infrared Technologist, Mr. E. F. Deesing and Mr. E. Neu of the Structural Alloys Section, and Mr. G. McConnell of the Nondestructive Test and Inspection Section for constructive criticism and suggestions is greatly appreciated.

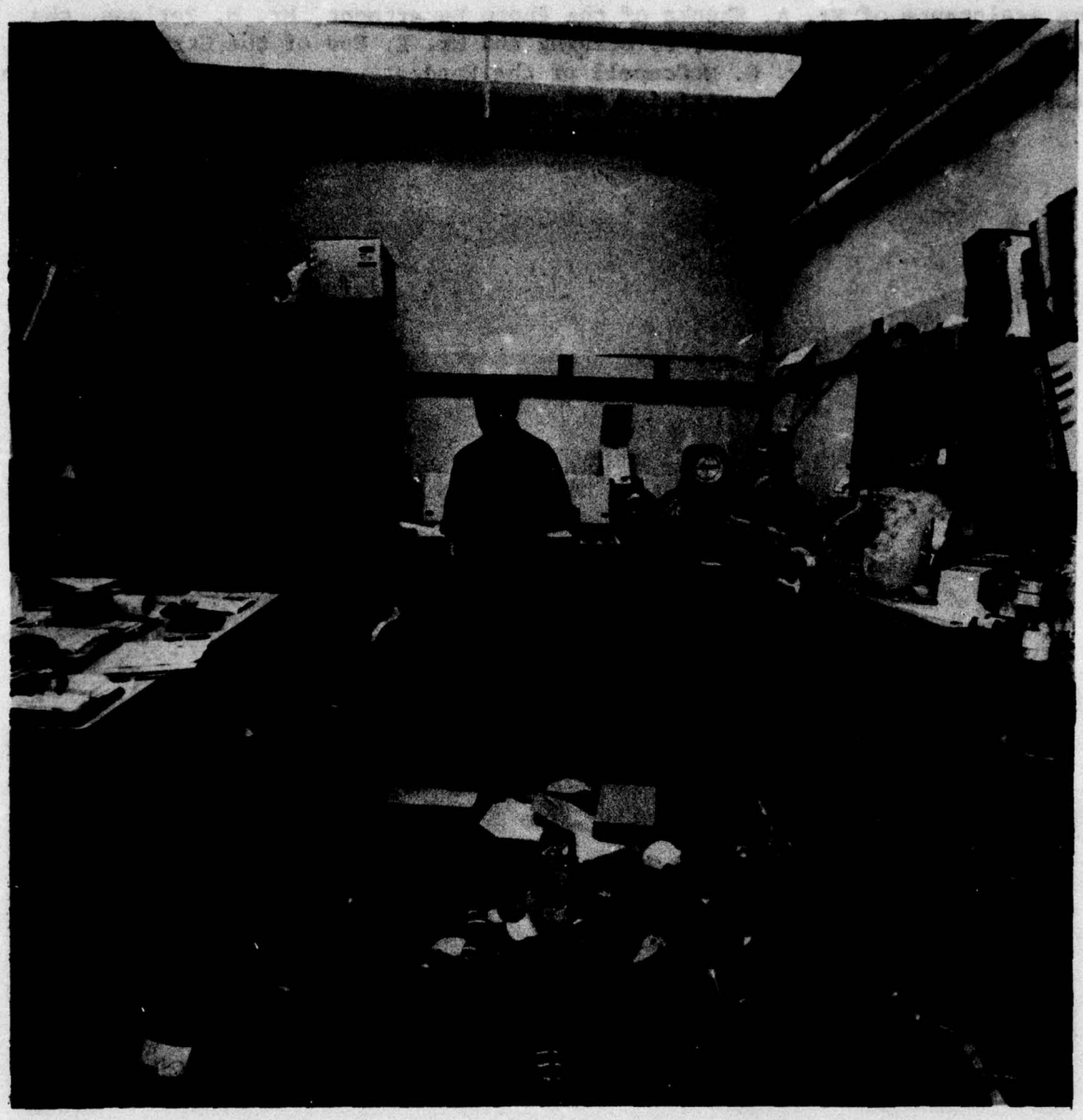

Figure 1. Room Where the Explosion Occurred

Figure 2. Adjacent Hallway with Portion of Cylinder and Steel Bands

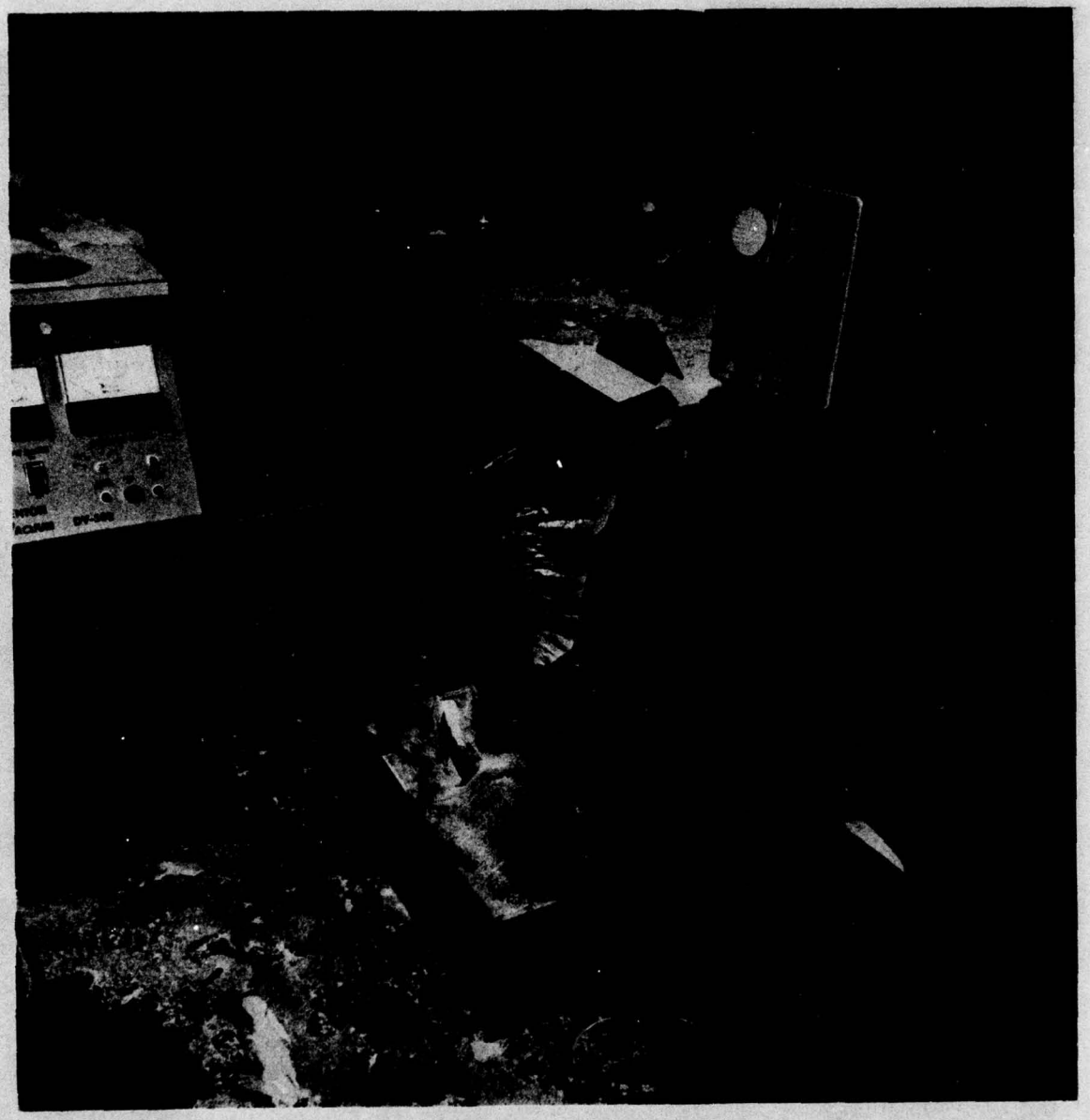

Figure 3. Damage to Adjacent Room

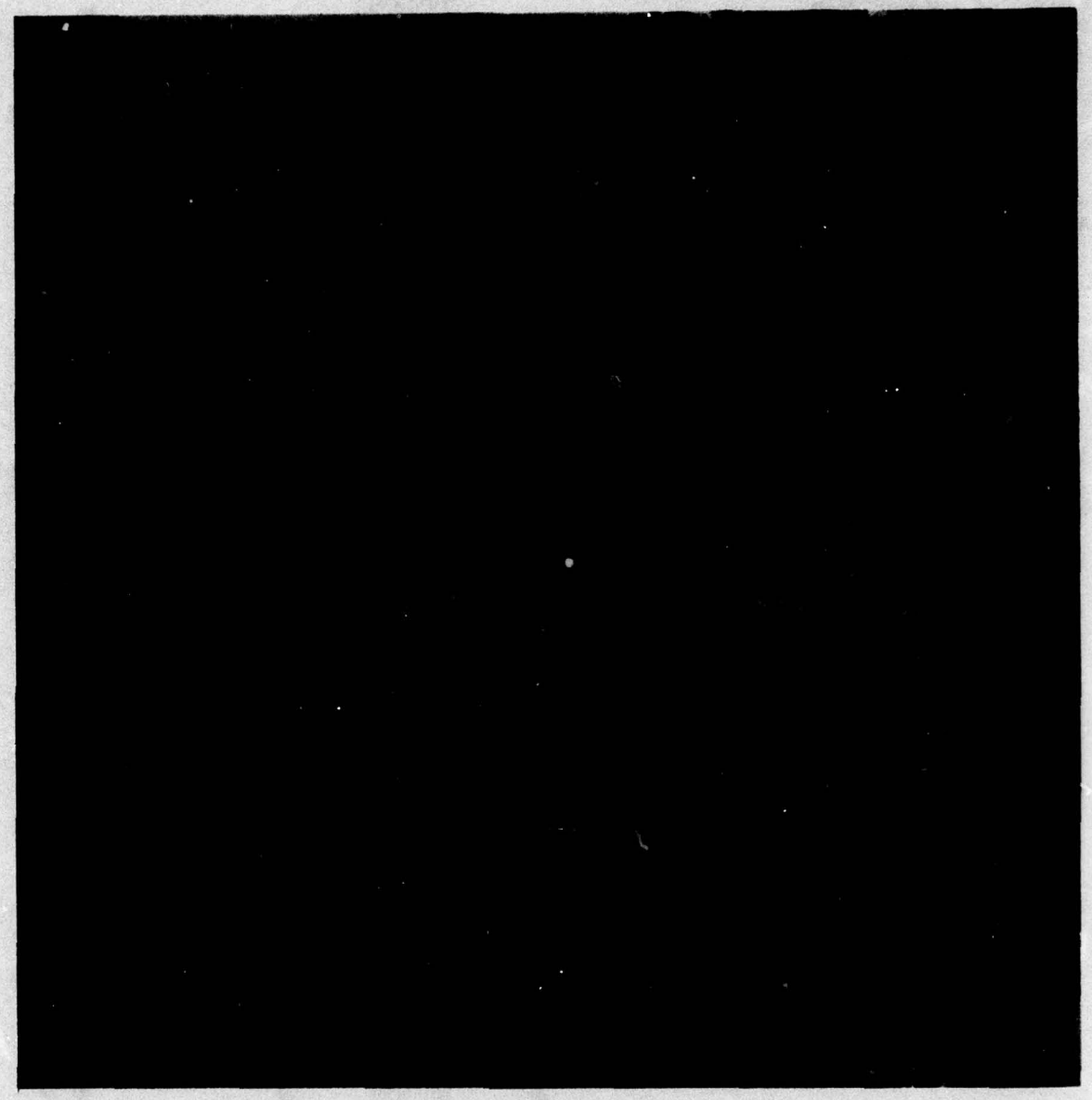

Figure 4. Typical G-276 LOX Cylinder in Stand Near Some Damage in Hallway.

Figure 5. Parts of the Exploded Cylinder

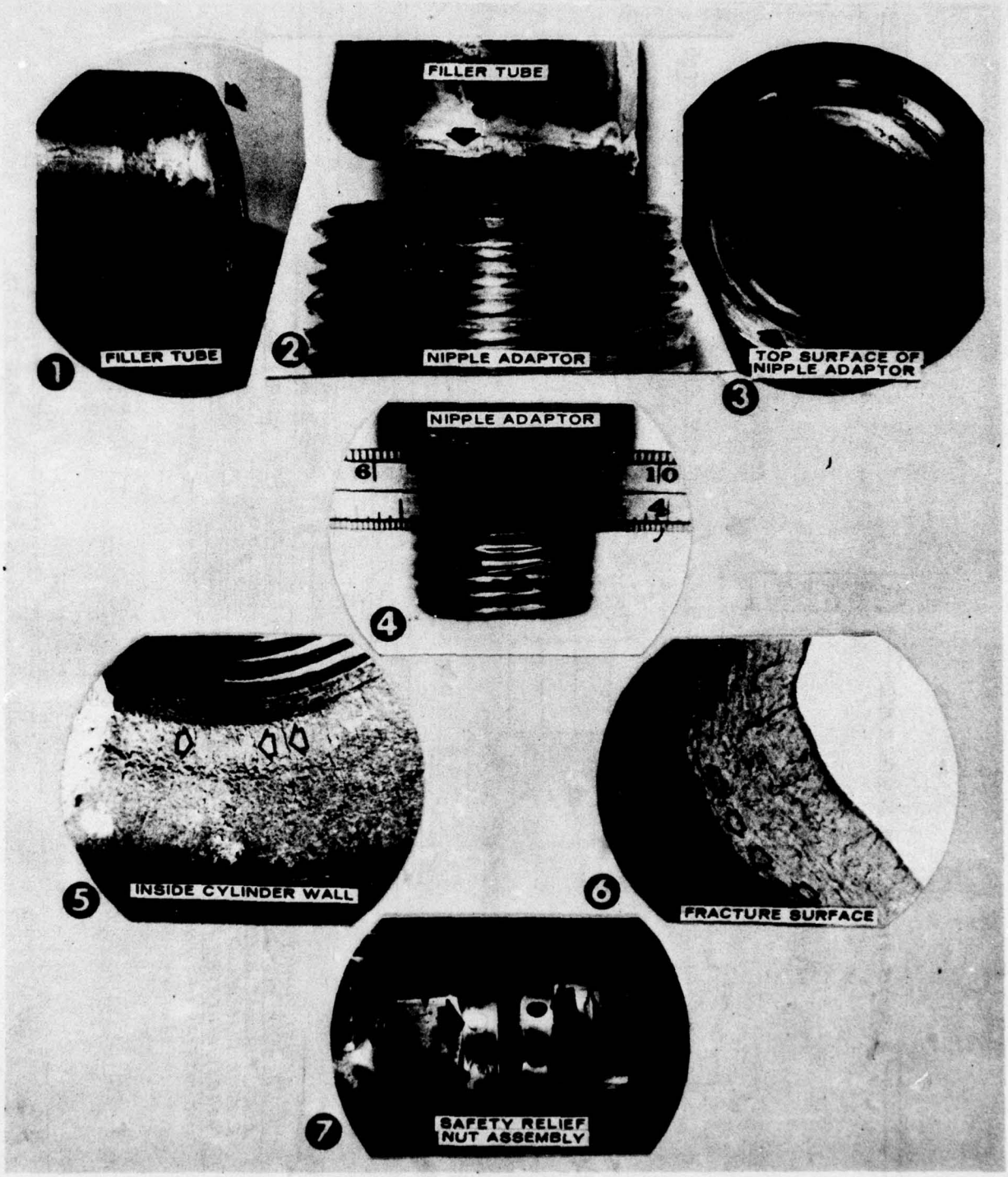

Figure 6. Detailed Photos of the Exploded G-276 Sampler

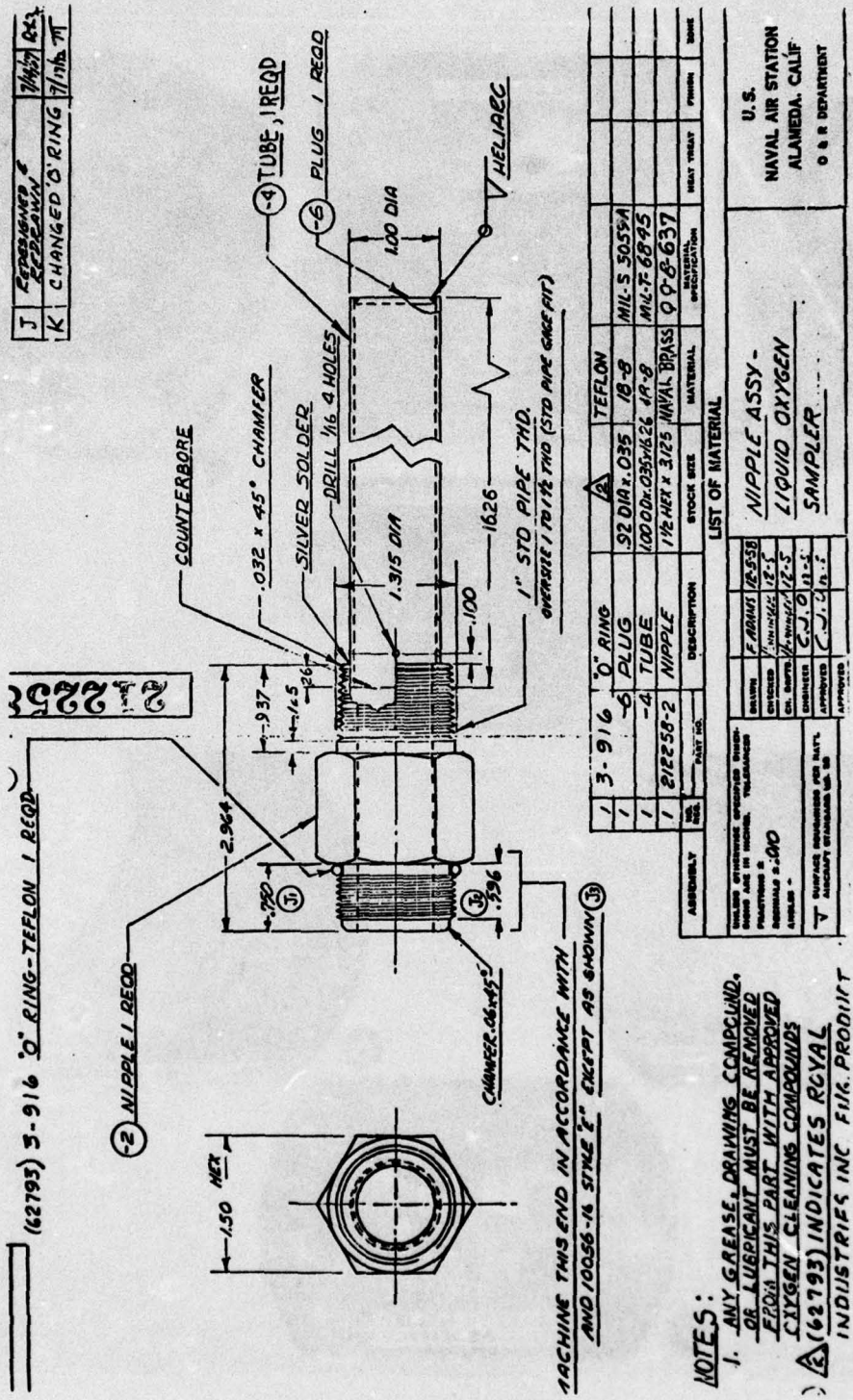

Figure 7. Specification Drawing of Nipple Assembly

APPENDIX A

INSPECTION OF G-276 LIQUID OXYGEN SAMPLER CYLINDERS

APPENDIX A

INSPECTION OF G-276 LIQUID OXYGEN SAMPLER CYLINDERS

1. Remove nipple assembly from the sampler cylinder.

2. Check external silver solder joint (refer to U. S. Naval Air Station, Alameda, California, O&R Department Drawing No. 212258 of 5 December 1958) for any irregularities between the nipple and the stainless steel tubing and the welded joint of the bottom cap. If the solder joint or the weld area has any defects such as insufficient solder, cracks, or visible porosity, discard the unit or send it to the shop for reworking.

3. Check stainless steel tubing internally (by inserting a right-angled scriber) to see if properly recessed (counterbored) 0.26" (0.66 cm) into nipple as shown in the No. 212258 drawing. If the silver solder joint is defective and/or the tubing is not recessed properly, it is emphasized that the unit should be discarded or reworked to conform to the above drawing.

4. If the valve safety disc is backed by a fusible alloy (drilled holes filled with metal), this material MUST be removed. The purpose of the fusible alloy is obviated since the intent of the G-276 sampler is not for the storage of compressed gases under high pressures in environments of extreme heat. The high-capacity packless cylinder valve used in G-276 LOX samplers MUST be fitted with an UNBACKED safety disc. Check the cylinder valve safety disc (Specification MIL-V-9439A) by removing the nut on the side opposite the valve outlet to see if the safety disc is the proper thickness (.00615 - .00665 in.) or if it bears a burst strength marking of 2700 to 3000 psi.

5. A suggested alternative to the present valve used on G-276 LOX samplers is to replace this valve with a modified high capacity packless cylinder valve with an unbacked safety disc assembly to which has been added a 2000 psi maximum pressure gauge drilled and tapped into the safety bore. The gauge will permit instantaneous detection of any excess pressure within the cylinder.

6. If, at any time, it is noted that the steel protection bands are broken on a G-276 LOX sampler, the cylinder should be discarded. Check the date when the cylinder was last hydrostatically tested. If outdated (5 years), send cylinder to the Naval Air Rework Facility for reworking and hydrostatic testing.

7. In the sampling operation, after filling the sampler with LOX, the cylinder should be examined for any evidence of frost appearing on the bottom or

excess frost near the top stem. Should this occur, the sampler should be vented to atmosphere immediately and resampling should be performed with an alternate sampler. The defective sampler should be checked as stated above in paragraphs 1 to 6 and reworked accordingly. In the case of the modified valve suggested under paragraph 5, a visual check on the pressure build-up should be made and excess pressure vented to the desired 500 psi.

NOTE: An eddy-current non-destructive technique for inspecting the stainless steel tube and nipple assembly has been suggested. When details of this procedure have been established, the technique will be available to facilitate the inspection of G-276 LOX cylinders.

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