SECTION IX

SAFETY

A. PURPOSE

The purpose of this section is to acquaint test site personnel with the hazards inherent in the propellant loading system and to recommend safe working practices and precautions that will be practical, economical, and compatible with existing Air Force regulations.*

B. THE PLS FACILITY

The Propellant Loading System proper is contained within the propellant terminal, a pipe tunnel, and the missile silo. Control and service elements of the system, however, extend beyond this locus to the equipment terminal, the tunnels, the Control Center, and the vent-and-supply trunks at ground level. The hazard area during the propellant system tests should thus include:

(1) Specific portions of the underground launch complex and tunnels beyond the entrance from the Control Center.

(2) The surface area within a specified distance of the missile silo opening or vent trunks.[1]

The hazardous areas involved for each test are shown in Figures IX-a, IX-b, and IX-c.

C. HAZARDS

The PLS facility and its components are so designed that the usual industrial hazards can be readily controlled by accepted industrial safety practices, i.e., good housekeeping, careful working practices, and intelligent supervision.

The contents of the propellant system, however, are hazardous. Explosion, fire, toxication, and dermatological injury can occur.

1. Explosion

A chemical reaction involving liquid oxygen or an overpressure in a gas system can result in explosions.

*References are listed at the end of this section.

a. Liquid oxygen itself is stable against detonation. A mixture of liquid oxygen and any combustible material, particularly carbonaceous fuels and lubricants, however, presents an explosion hazard. Even a frozen mixture can be detonated by mechanical shock or electrical or static spark. Semiliquid gels or slurries are especially dangerous. Liquid-oxygen-saturated metal chips or rust flakes will detonate.[2] The only safegua d against this hazard is to isolate the liquid oxygen in a chemically clean, tight, self-contained system. Gases admitted to such a system must be free of combustible contaminants.

b. Safety relief valves and rupture disks have been included in the design to protect the systems against abnormal gas pressures. Note that the relatively large volumes of gas generated when liquid oxygen and nitrogen warm and vaporize can result in hazardous pressures if not properly vented.[3] Relief valves must be mechanically free to operate at the proper set points, and rupture disks must be of the designed gauge and unobstructed.

2. Fire

RP-1 fuel is highly combustible and gaseous oxygen will support combustion. These constitute the major fire hazards in the system.

a. RP-1 fuel resembles kerosene, is moderately volatile, has a flash point of 110°F, and is heavier than air. Thus, RP-1 vapor will tend to collect in "pockets," and if air (oxygen) and heat are present, the gas can flash-ignite. Fuel leaks are therefore a source of a hazardous, combustible gas. Personnel must not rely on hydrocarbon vapor detectors; RP-1 vapor is too heavy to be readily detected.

We recommend that the fuel be colored with a neutral agent (to aid in detecting leaks), that the air circulation system be operated at maximum rate during fuel transfer (to exhaust any vapors), and that smoking be prohibited when the system contains fuel. Open flames (welding, etc.) or ungrounded, unshielded electrical equipment (power tools, etc.) should not be used near fuel lines and equipment.

FIGURE IX

HAZARD AREAS IN OSTF LAUNCH CONFIGURATION

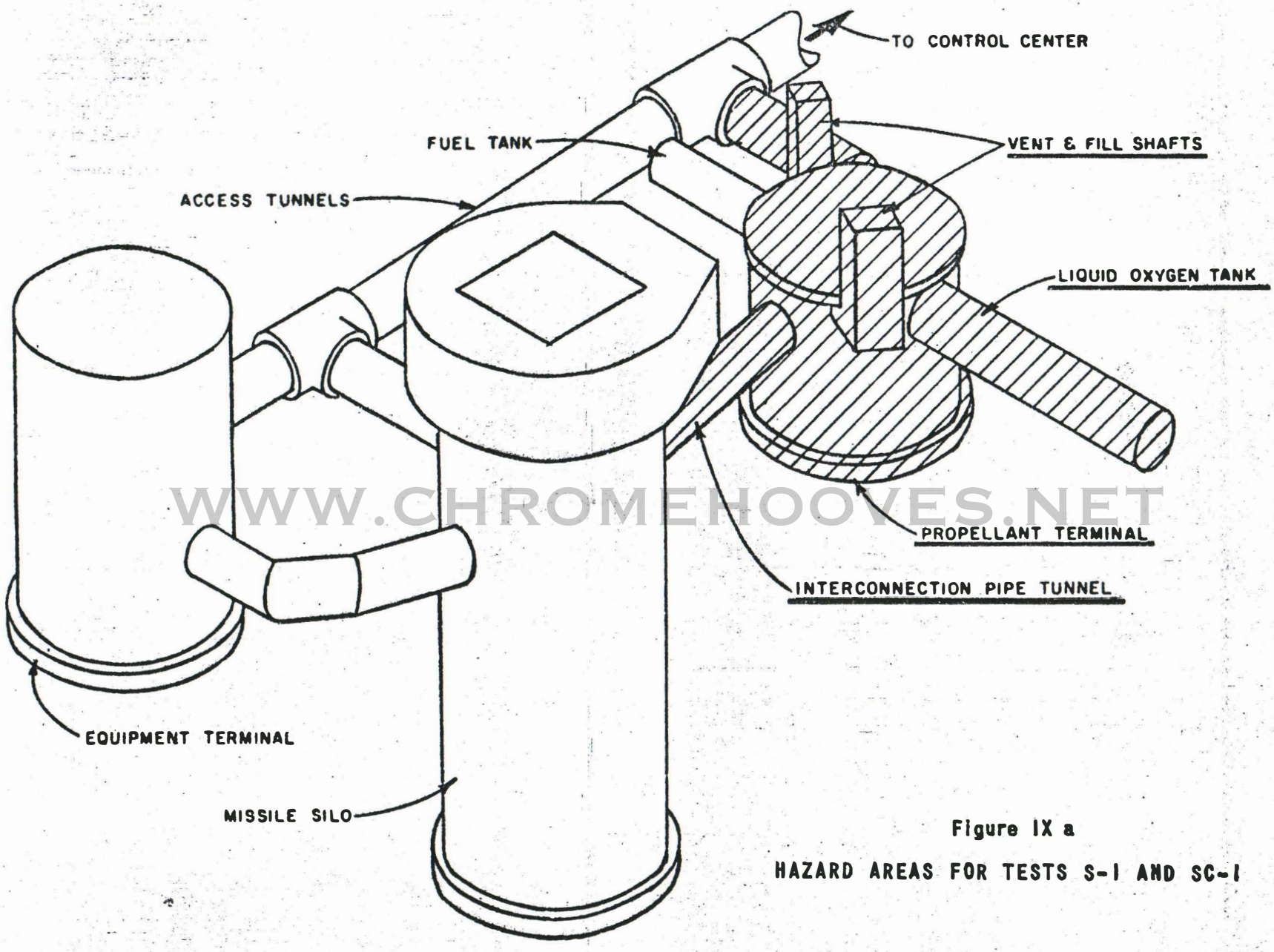

Figure IX a

HAZARD AREAS FOR TESTS S-I AND SC-I

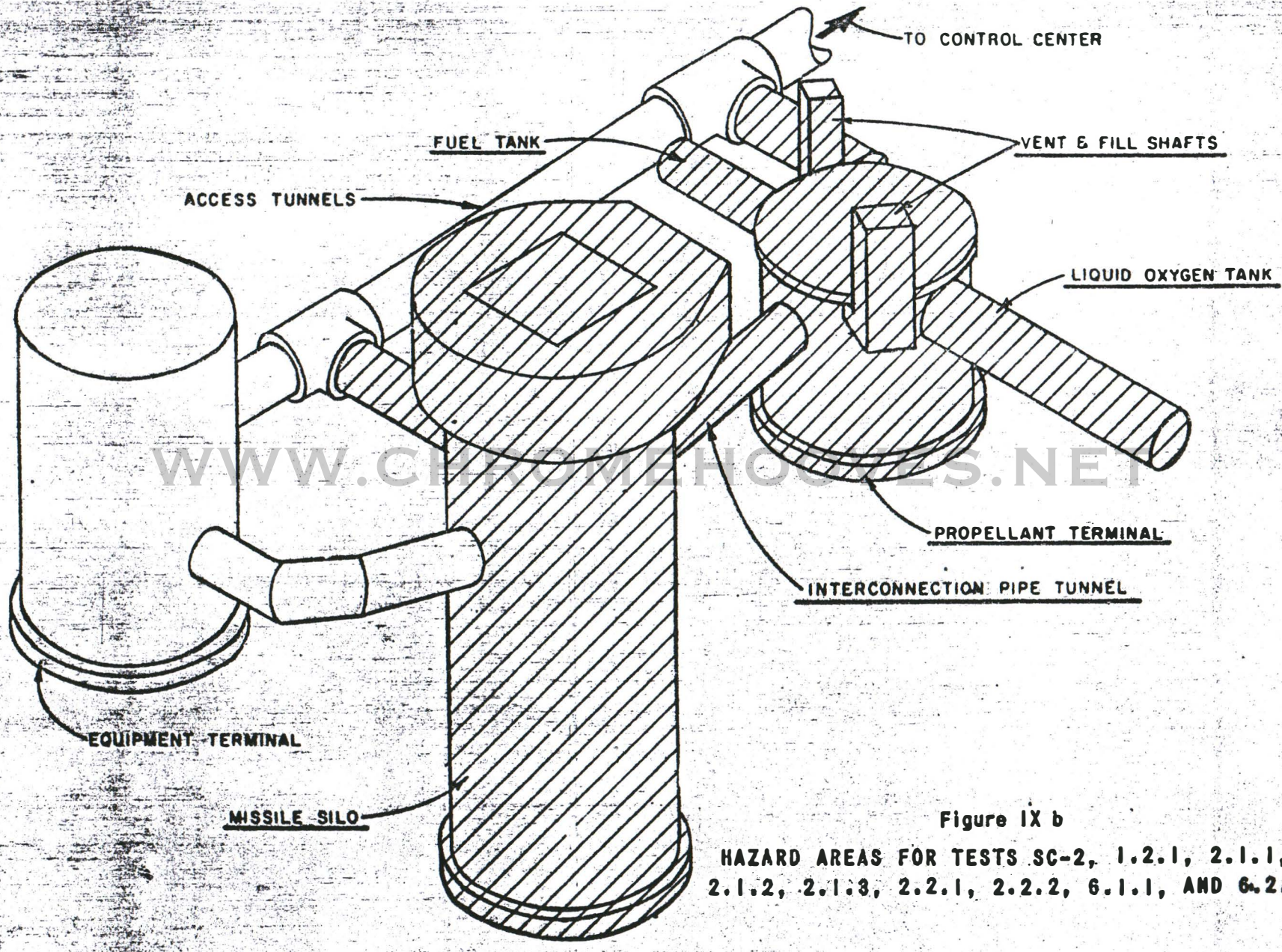

Figure IX b

HAZARD AREAS FOR TESTS SC-2, 1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.2.1, 2.2.2, 6.1.1, AND 6.2.5

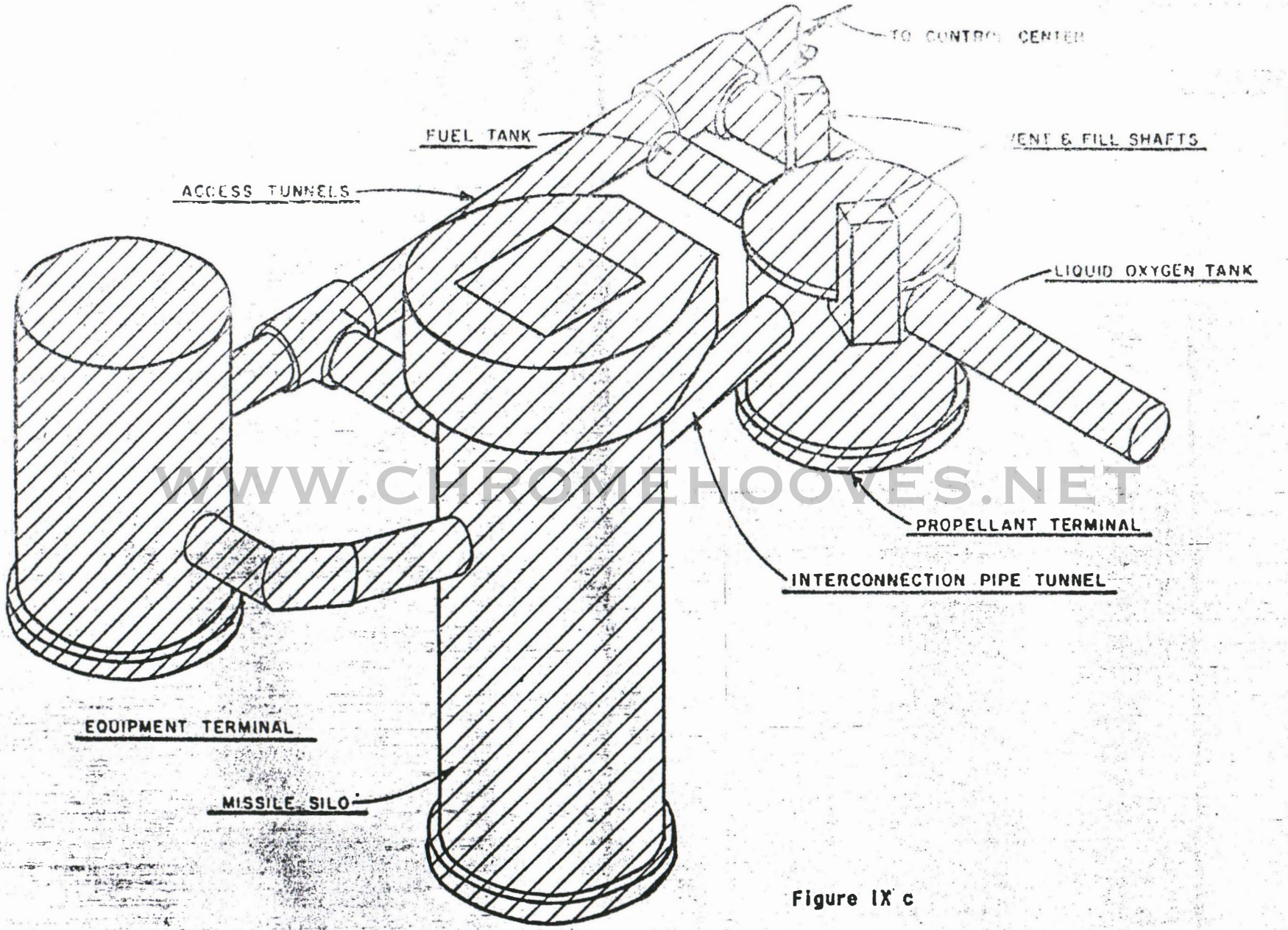

Figure IX c

HAZARD AREAS FOR TESTS 1.2.2, 2.[illegible], 2.2.3, 2.2.4, 2.2.5, 2.2.6, 2.2.7, 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.2.6, AND PLS

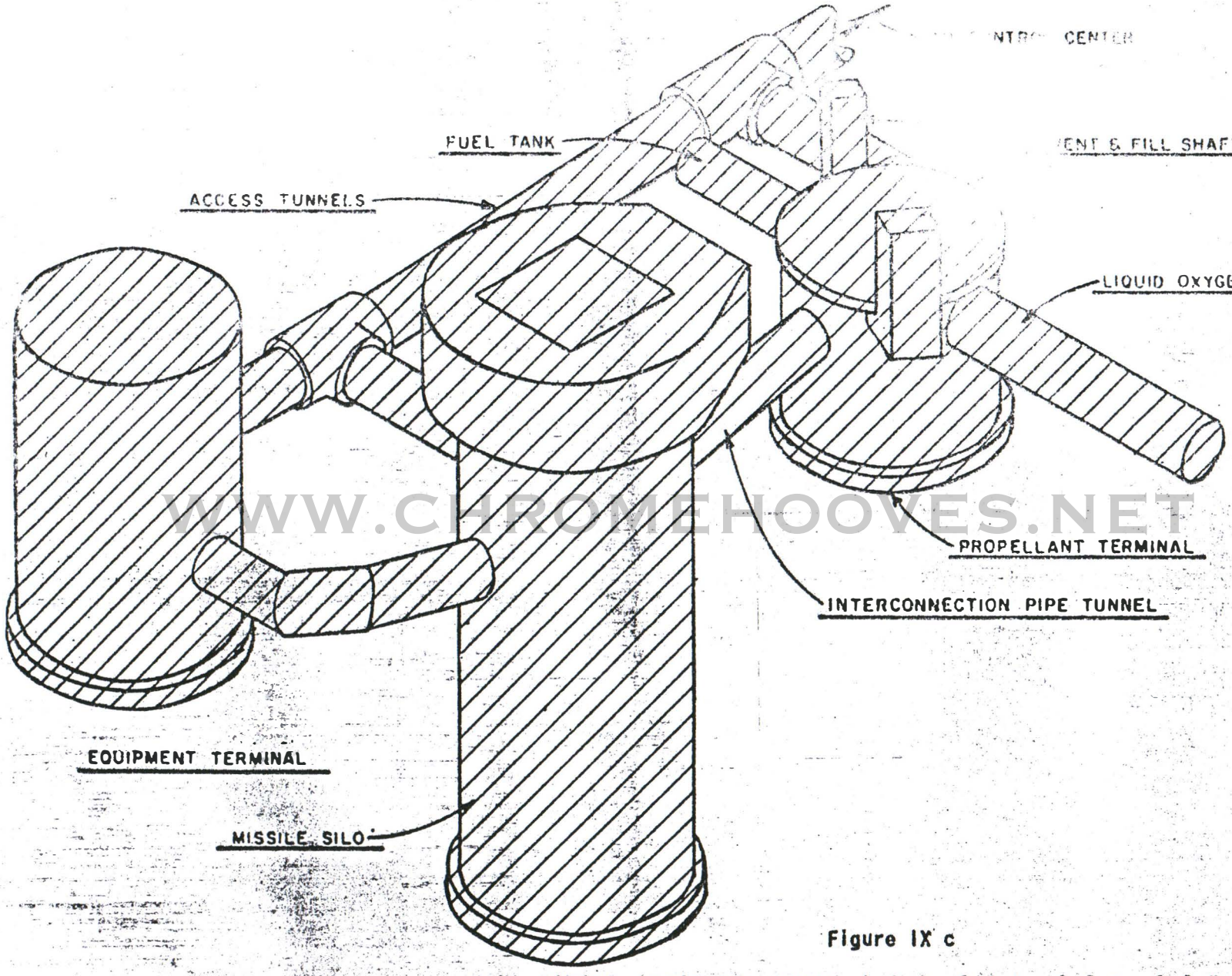

Figure IX c

HAZARD AREAS FOR TESTS 1.2.2, 2.2.3, 2.2.4, 2.2.5, 2.2.6, 6.2.3, 6.2.4, 6.2.6, AND PLS

b. Gaseous oxygen supports combustion fiercely even though it does not "burn" by itself. Materials not normally combustible will burn readily in an oxygen-rich atmosphere. The gas will saturate clothing, wood, brushes, and like articles that then could be moved to "safe" areas and inadvertently ignited.

An oxygen analyzer has been installed in the propellant terminal exhaust vent to sense abnormal concentrations of the gas. Additional portable "sniffers" should be used by personnel entering an area where a liquid or gaseous oxygen leak condition is suspected, and the ventilation system should be set at maximum. The use of open flames, ungrounded, unshielded electrical equipment, or tools or boots that are not spark-free cannot be permitted in areas of abnormal oxygen concentration.

3. Toxication

The confined, underground construction of the facilities increases the danger of respiratory injuries if the ventilation system fails or if abnormal gas concentrations suddenly develop.

a. Fuel vapor is heavier than air, and fuel spills in a poorly ventilated space can result in a toxic atmosphere. The narcosis is sickening but not fatal, and recovery is rapid when exposure is terminated. Concentrated fuel vapor is easily identified by smell.

b. Oxygen, nitrogen, and helium gases are lighter than or close to the density of air; therefore, any free quantities should be readily exhausted by the ventilation system. A gas vessel or line rupture or vaporization from a large liquid oxygen or nitrogen spill could create a temporary local gas concentration, however. Personnel should anticipate such a condition after a malfunction or accidental spill and thoroughly ventilate and test with "sniffers" before entering the space.

4. Dermatological Injury

Contact with the liquid gases and RP-1 fuel can injure skin and eyes.

a. More than momentary skin contact with fuel may produce burning, blistering, and drying of skin; hence, there will be a danger of secondary infection. Protective clothing, neoprene gloves, and face shields will minimize this hazard. Exposed areas should be thoroughly washed with water at the eye fountains and safety showers; then medical attention should be sought.

b. Liquid oxygen and nitrogen are cold, and more than momentary contact with the skin may produce serious "burns." Personnel working where spills and splashes are possible must wear protective gear, including asbestos gloves over neoprene liners, clean, long-sleeved cotton clothing, face shields, and high-top nonsparking boots. Pants legs must be outside the boots. Rubber aprons are an additional recommended article of protective clothing. Exposed areas should be thoroughly washed with water at the eye fountains and safety showers; then medical attention should be sought.

D. SAFETY PRACTICES

The following safety practices are recommended to guard against personel injuries or damage to equipment and facility during the tests. We feel that these measures are practical and necessary for safe test accomplishment. These practices should be observed during the delivery, loading, and transfer of propellant; in other words, if propellant and gases are in the area of the propellant loading system, a hazard condition should be considered extant within the PLS facilities.

1. Personnel

a. Prior to the beginning of a PLS test, the Test Conductor (ADL) should prepare and submit to the Test Manager (STL) a list of authorized test participants.

f. Portable "sniffers" that can detect the presence of abnormal amounts of oxygen, nitrogen, or helium in a space should be available to personnel for use in the propellant facility.

g. The propellant terminal and missile silo should be equipped with safety showers, eye fountains, fire blankets, stretchers, emergency lights, first-aid material, and fire extinguishers.

3. Warnings

a. Personnel should be instructed about the Air Force warning and clearing systems effective at Vandenberg Air Force Base.[6]

b. The Test Conductor (ADL) should not begin any test operation until the proper area clearing and warning procedures have been complied with.

4. Cleanliness

a. The PLS facilities, equipment, tools, parts, test gear, and other contents should be clean (i.e., grease-free and in good order) before and during tests.

b. Personnel working in the PLS facilities should maintain personal soap-and-water cleanliness.

c. Prior to the start of the tests, the PLS will have been accepted as clean and tight. These conditions must be maintained. If it becomes necessary to open the liquid gas or gas systems for repair, the following precautions should be mandatory:

(1) The area surrounding the repair point should be cleaned with trichlorethylene and vacuumed dry.

(2) Clean, nonsparking tools and approved, sealed repair parts should be at hand.

(3) A one- to two-psig blanket pressure should be established in the line or vessel at the repair point and maintained during the repair operation.

(4) The repair operation should be done with surgical care as to cleanliness.

(5) The line or vessel should be purged and pressure-tested after completion of repairs.

If repairs have been such that contamination has been unavoidable, the contaminated section should be completely cleaned as detailed in the specification for "Installation, Preparation and Testing of the Propellant Loading System."[7]

This cleaning includes a flush of the system with clean liquid nitrogen, purge and blowdown with clean, dry nitrogen gas, and analysis of the influent and effluent substances. If contamination is so extensive that flush and purge cleaning is not effective, the necessary sections of the system will have to be disassembled for piece-by-piece cleaning.

d. Portable "black light" units and clean trichlorethylene solvent should be available for PLS facilities inspection, cleaning and repair.

e. Personnel using trichlorethylene should wear neoprene gloves, a rubber apron and a face shield. Personnel should avoid inhaling fumes or using the solvent in poorly ventilated areas.

5. Maintenance

a. Only nonsparking tools and equipment should be used within the facilities after the start of the PLS tests. Pneumatic power tools are preferred over electrical types.

b. Replacement parts should be received for installation sealed and approved as to cleanliness by the quality-control laboratory.

c. A record of maintenance work required and done should be kept as part of the test log.

d. The lubricant and hydraulic fluid recommended for use in liquid oxygen and helium subsystems of the PLS are, respectively, Fluorolube and Houghts Safe Oil 620.

e. Attention should be paid to the position of valves and the relief of pressure or vacuum before any piping system is opened.

f. Cutting, welding and machining work should not be done in charged PLS facilities. If necessary, these tasks require maximum ventilation, fire-fighting equipment at hand, and a thorough area clean-up.

6. Smoking

a. Smoking should be prohibited in the PLS facilities after the completion of construction acceptance. We recommend this mandatory rule to eliminate any chance of "mistakes" and that all smoking materials be surrendered at the entrance from the Control Center.

b. Food, chewing gum, tobacco, and like absorbents of oxygen gas should also be prohibited from the PLS facilities.

E. REFERENCES

The references in the text refer to the applicable sections of the following publications:

1. 1st Missile Division, Vandenberg Air Force Base, 1 MDM 55-1, "Missile Operations" (confidential manual).

2. Douglas Aircraft Company, AFR 11-30, 2-59 Doug-0080A, "The Strange Case of Liquid Oxygen" (unclassified film).

3. Liquids Propellants Information Agency, Johns Hopkins University, "Liquid Propellant Safety Manual" (unclassified manual).

4. 1st Missile Division, Vandenberg Air Force Base, 1 MDM 58-7, "Safety Caps" (unclassified regulation).

5. 1st Missile Division, Vandenberg Air Force Base, 1 MDM 58-8, "Protective Clothing for Liquid Oxygen and Nitrogen Handlers" (unclassified regulation).

6. 1st Missile Division, Vandenberg Air Force Base, 1 MDM 58-4, "Warning Devices" (unclassified regulation).

7. Arthur D. Little, Inc., "Specification of the Propellant Loading System for the Operational System Test Facility."

F. BIBLIOGRAPHY

The following publications, in addition to those listed above, report liquid propellant system hazards and safety procedures. All are available from the listed publisher. A copy of each will be available in the ADL field office, Vandenberg Air Force Base.

1. 1st Missile Division, Vandenberg Air Force Base, 1 MDM 58-5, "Missile Accident Emergency Team"; 1 MDM 58-6, "Reporting Hazards in Missile Activities"; STD 59-2-14, "Missile Safety."

2. Directorate of Missile Captive Test, AFFTC, Edwards Air Force Base, FTR-TM-58-1, "Safety Procedures for Rocket Propellants."

3. Lewis Flight Propulsion Laboratory, NACA, "Rocket Laboratory Safety and Design Manual."

4. Pan American World Airways, Guided Missile Range Division, Patrick Air Force Base, AFMTC-TR-58-7, AD-TB4277, "Manual for Handling Missile Propellants."