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ESD EXHIBIT 61-3C

Revision C

Supersedes all previous issues

5 March 1962

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**PERMISSIBLE CONTAMINATION LIMITS AND INSPECTION CRITERIA
FOR LIQUID OXYGEN, LIQUID NITROGEN, RP-1 FUEL,
GASEOUS OXYGEN, GASEOUS NITROGEN,
INSTRUMENT AIR AND HELIUM, COMPONENTS AND HANDLING SYSTEMS**

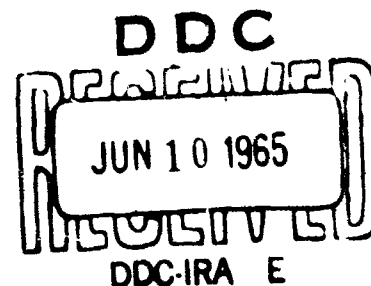
Revision C

(Supersedes all previous issues)

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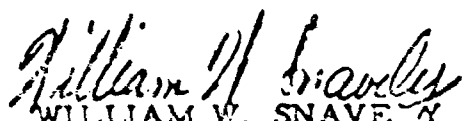
Headquarters
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Air Force Systems Command
United States Air Force

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PERMISSIBLE CONTAMINATION LIMITS AND INSPECTION CRITERIA
FOR LIQUID OXYGEN, LIQUID NITROGEN, RP-1 FUEL,
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INSTRUMENT AIR AND HELIUM, COMPONENTS AND HANDLING SYSTEMS

1. **PURPOSE.** To establish a document for incorporation into Air Force Ballistic Missile program contracts which will provide a standard exhibit outlining the cleanliness criteria, and inspection procedures to assure the desired cleanliness level of components and systems handling liquid oxygen, liquid nitrogen, gaseous nitrogen, helium and RP-1 fuel utilized in ballistic missiles.
2. **SCOPE.** This revision to AFBS 61-3 applies only to Air Force Ballistic Systems Division and to all Air Force contractors involved in, or required to support, that phase of activation for Air Force Ballistic Missile programs from BOD to TAD. In those cases where SATAF Commanders must exercise a judgment factor upon acceptance of Propellant Loading Systems at or prior to BOD, there shall be no instances where Propellant Loading Systems will be accepted (by a blow down test) if any solid particles exceed 1000 microns in their greatest dimension.
3. **COORDINATION.** This exhibit has been coordinated by Staff and Weapon System Program Offices of BSD.
4. **IMPLEMENTATION.** Existing contracts will be amended to replace present contractual documents as rapidly as possible consistent with the best interests of the Government, and no delay to provisioning and procurement.
5. **DISTRIBUTION.** Additional copies of this exhibit may be requisitioned from the Air Force Ballistic Systems Division (AFSC), attention of DCLMT.


WILLIAM W. SNAVELY
Colonel, USAF
Deputy for Technical Development
Hq Ballistic Systems Division (AFSC)

1.0 SCOPE.

This exhibit covers:

- a. The inspection procedures and permissible contamination limits for individual components of liquid oxygen, liquid nitrogen, RP-1 Fuel and service gas handling systems of all weapon systems utilizing LOX and RP-1.
- b. The inspection procedures and permissible contamination limits for complete liquid oxygen, liquid nitrogen, RP-1 fuel, and service gas handling systems, (ground systems only).
- c. The inspection procedures and permissible contamination limits for supporting and maintenance activities, including MAMS, the LOX generating facility and fluid servicing equipment.

2.0 APPLICABLE PUBLICATIONS AND DEFINITIONS.

a. Military Specifications:

MIL-P-27401	Propellant, Nitrogen, Pressurizing, 7 November 1960
MIL-T-27602	Missile Grade Trichloroethylene, 1 May 1961
MIL-P-25508	Propellant Oxygen, 7 November 1960
MIL-R-25576	Fuel; Rocket Engine, Grade RP-1, 23 January 1959

b. Bureau of Mines Standard for Helium:

Grade A	99.995% Pure
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c. Filter Rating:

Absolute filter rating specifies removal of all particles and fibers whose smallest diameter is larger than the specified pore size for the filter.

d. Demineralized Water.

For purposes of this specification, demineralized water is defined as water having a total maximum of 20 ppm by weight

suspended and dissolved solids, pH of 5.5 to 9.0. The water shall be filtered through a filter with an absolute rating of 40 microns.

e. System.

A collection of components assembled in such a manner as to allow them to interact with each other to perform some specified function.

f. Components.

A component is an integral unit, portion, of an assembly or system. Examples are tubes, ducts, tanks, valves, actuators, reservoirs, accumulators, etc.

g. Fiber.

A fiber is defined as any material having a diameter of 40 microns or less and a length to diameter ratio of approximately 10:1.

h. Solid Particle.

A solid particle is defined as any solid material which cannot be classified as a fiber. The size of a solid particle shall be determined by its largest dimension.

i. Test Fluids.

When oxygen, nitrogen, helium, RP-1 or other fluids are used as inspection test fluids, they shall comply with the latest issue of the applicable specifications listed in paragraph 2. Fluids should be filtered through a 40 micron absolute rated filter, or smaller, before being introduced into components or systems being tested, and shall conform to the use limits contained in section 5b.

3.0 COMPONENT INSPECTION.

Cleanliness of components shall be verified by the procedures of Inspection Numbers 1, 2, and 3, as specified below. Wherever possible, Inspection Number 1 (utilizing the solvent rinse method) shall be used for detecting particle size and quantity. Inspection Number 4 shall be

resorted to as a means of inspection only in those instances where Inspections Number 1 and 3 are impossible or impractical. If a component fails to pass inspection, the component shall be recleaned. Inspection Number 5 shall be conducted as a referee inspection, by depot or other qualified testing agency, where the level of hydrocarbon contamination is questioned after completion of Inspections Number 3 or Number 4. The results from Inspection Number 5 shall be final and binding where any difference occurs in the interpretation of the results of Inspections Number 3 or Number 4. Only components of LOX, N₂ and helium systems will be inspected for hydrocarbon contamination. Total hydrocarbon contamination permitted shall be as specified in Inspection Number 5.

a. Permissible Contamination Limits for All Components:

(1) Cleanliness Ascertained by Flush or Solvent Rinse Tests:

LOX and RP-1

<u>Solid Particles</u>	<u>Size Microns</u>	<u>Number</u>
	300-500	25 per sq ft area
	500-1000	5 per sq ft area
	Greater than 1000	0
<u>Fibers</u>	750-2000 length	50 per sq ft area
	2000-6000 length	5 per sq ft area
	Greater than 6000	0

Total Solids and Fibers: 5.0 milligrams per sq ft

Gaseous Nitrogen, Instrument Air, and Helium:

<u>Solid Particles</u>	<u>Size Microns</u>	<u>Number</u>
	300-500	15 per sq ft area
	Greater than 500	0
<u>Fibers</u>	Greater than 2000	0

Total Solids and Fibers: 2.0 milligrams per sq ft

(2) Cleanliness Ascertained by Wipe Test Immediately After Cleaning or Prior to Packaging Installation:

No particles greater than 300 micron size.

No fibers greater than 40 micron diameter x 4000 micron length.

No hydrocarbons, (see paragraph 3d).

(3) Cleanliness Ascertained by Wipe Test After Initial Acceptance and Installation:

LOX and RP-1:

No particles greater than 750 micron size.

No fibers greater than 40 micron diameter x 6000 micron length.

No hydrocarbons, (see paragraph 3d). (LOX only).

Gaseous Nitrogen, Instrument Air, and Helium:

No particles greater than 400 micron size.

No particles greater than 40 micron diameter x 6000 micron length.

No hydrocarbons, (see paragraph 3d).

b. Inspection No. 1 - Particulate Inspection:

Inspection of cleaned components shall be performed by solvent rinse method where possible. This will generally be accomplished during the final cleaning stages and just prior to the drying operation. The effluent shall be examined for particles by the Millipore method, or equivalent method. For this purpose the final solvent rinse shall be performed with filtered trichloroethylene, demineralized water or equivalent, using a measured amount of 200 milliliters of rinse fluid per square foot of component inner (or effective) surface for the rinse. Any component having less than one (1) square foot of internal surface area will be considered as being one square foot. The solvent rinse shall be performed by either sloshing or agitating the fluid around the inside surface of the component to insure dissolution of particles.

Effluents which contain any particles in excess of the criteria applicable in paragraph 3a (1) shall cause component recleaning and reinspection.

c. Inspection No. 2 - Visual.

All equipment, pipes and components shall be examined for evidence of corrosion products, metal chips, scale, weld scale, oil, grease, paints, preservatives, decals or other contamination or foreign matter. The use of special devices to visually examine normally inaccessible areas of vessels and pipe is required. RP-1 fuel system equipment pipes and components may have a light film resulting from a rust-proofing treatment which is not a contaminant.

d. Inspection No. 3 - Ultra-Violet ("Black Light").

Visual inspection with the aid of an ultra-violet light source (2500 to 3700 angstrom units) shall be accomplished on all accessible surfaces to determine the presence of petroleum-type hydrocarbons.

Attention is called to the fact that all contaminants do not fluoresce under ultra-violet light and this test can be considered only as an aid in detection of contamination. The contractor's personnel shall be qualified in the use of the black light. Any evidence of fluorescence shall be cause for recleaning the item or reverting to Referee Test No. 5, paragraph 3f. This inspection requirement is not applicable to the fuel system.

e. Inspection No. 4 - Wipe Test.

The wipe test shall be made at each end of each clean section of pipe and normally accessible interior surfaces of each component using a new clean filter paper (Whatman No. 42, S and S No. 602, or equal). This test shall consist of at least two movements of the filter paper across one square foot of surface. No fluorescence shall be observed when the filter paper wipe sample is subject to the previously described ultra-violet inspection. The area

covered may be reduced as necessary where small lines and parts are involved. A representative sample (a blank) of the filter paper used shall be checked for fluorescence and particle count prior to conducting this test. Any evidence of contamination in excess of the above-described limits shall require the item to be recleaned and reinspected as outlined above. Wipe samples taken from RP-1 fuel components are not to be subjected to fluorescence test.

Wipe test samples which include any particles in excess of the criteria mentioned in paragraphs 3a (2) and 3a (3) above shall cause component recleaning and reinspection.

- f. Inspection No. 5 (Referee Tests) Infrared and/or Gravimetric Quantitative Measurement for Non-Volatile Hydrocarbon in LOX System Components. (Depot Support or Equivalent Test Agency).
Note: This test is applicable only to cleaned components and is not to be utilized to determine system cleanliness.

The permissible non-volatile hydrocarbon contamination in any component tested in conformance with this procedure shall not exceed 2.5 milligrams per square foot of component internal surface area. In case the internal surface cannot be exactly computed, the internal surface area shall be estimated. The component shall be prepared for this test, free from all possible sources of hydrocarbon contamination. Everything used in direct contact with the component shall be free from hydrocarbon material, i.e., grease, oil, etc. The fluid or gas entrance and exit ends of the component, upon being removed from the system, shall be wiped with dry, clean cloth or absorbent paper. The inner surface, and any flange surface which contacts the system fluid or gas shall not be wiped. The ends of the component shall be covered with new polyethylene film which shall be taped in place in order to exclude all contamination as above. An appropriate apparatus, such as the one described below, shall be used for rinsing the component.

A large tripod stand shall be covered with aluminum foil and the foil rinsed twice with carbon tetrachloride or trichloroethylene.

A large sheet of aluminum foil shall be placed over the tripod and fashioned into a funnel to allow the carbon tetrachloride or trichloroethylene to be used for the rinse wash to run into a beaker placed beneath it. The funnel and the beaker shall be rinsed twice with carbon tetrachloride or trichloroethylene. The carbon tetrachloride or trichloroethylene used for rinsing and analysis shall be ACS or spectro grade or better with little or no absorption at 3.45 microns wave length and the aluminum foil shall be new foil previously checked for hydrocarbon contamination.

Both ends of the component shall be wiped with a clean cloth or absorbent paper moistened with carbon tetrachloride or trichloroethylene. The component shall be placed upright on the funnel. A carbon tetrachloride or trichloroethylene prewashed glass wash bottle employing a glass spout shall be used to rinse thoroughly the entire inner surface of the component. Approximately 200 milliliters of carbon tetrachloride or trichloroethylene per square foot of inner surface shall be used. The effluent solvent shall be examined by either of the following, or equivalent methods:

- (1) The collected carbon tetrachloride shall be measured and then analyzed as is, diluted, or concentrated as required by the analytical calibration curve limitations. The absorption at 3.45 microns shall be recorded and the corresponding concentration obtained from the analytical curve. This concentration is then used in calculating the results. Rocket fuel, RP-1, MIL-R-25576B, shall be used as the calibration standard. If concentration of the sample is required, a blank of the reagent carbon tetrachloride shall be concentrated equivalently and analyzed. Any hydrocarbons found in the blank shall be included in the calculation. Results shall be reported as milligrams of RP-1 per square foot of total washed surface of the component.
- (2) The collected carbon tetrachloride or trichloroethylene shall be evaporated to dryness and analyzed by the gravimetric method for volatile residue. - A blank sample of carbon tetrachloride or trichloroethylene used of the same volume shall also be run, evaporated and weighed in the same way and subtracted. Results shall be reported as milligrams of RP-1 per square foot of the total inner surface of the component.

- (3) Calculations. - Milligrams of RP-1 per square foot of total inner surface of the component shall be calculated by the following equation:

$$\frac{(\text{Milligrams RP-1 per Milliliter}) \times \text{Milliliters of Solution}}{\text{Square Feet of Surface Area Rinsed}} =$$

Milligrams of RP-1 per Square Foot

g. Certification.

Each component or component package which has been processed in accordance with this specification shall have attached evidence showing it meets cleanliness requirements. Evidence shall consist of a tag, label, or stamp incorporating the appropriate part cleanliness identification (reference paragraph 3h) the date of acceptance and the name or stamp of the responsible inspector. The tag, label or stamp shall be affixed in a manner that it will be destroyed should the contamination seal on the component be broken.

h. Parts Cleanliness Identification Instructions:

- (1) LOX Compatible Clean - Those items that have been cleaned, tested, inspected, identified and packaged so that they are suitable for installation into gaseous and liquid systems that come into contact with LOX.
- (2) Special Clean - Those items that have been cleaned, tested, inspected, identified and packaged so that they are suitable for installation into gaseous or liquid systems that do not come into contact with LOX, either directly or indirectly. No test is required for hydrocarbon. This applies to RP-1 fuel and hydraulic components.
- (3) Hydraulic Clean - Those items which are not functional can be identified as either Special Clean or Hydraulic Clean.
- (4) Normal Clean - Those items which are not identified in (1) through (3) above.

4.0 SYSTEMS INSPECTION. (GROUND SYSTEMS ONLY)

The system shall be judged clean when the permissible contamination limits quoted below are met. The liquids or gases used during cleanliness testing shall comply with the latest issue of applicable military or other specifications mentioned in paragraphs 2a and 2b. All liquid and gases used during cleanliness testing, except RP-1 fuel, shall be filtered through 40 micron absolute rated filters. These filters shall be located in the fill line between the transport vehicle and the fill connection into the system. RP-1 fuel shall be passed through a 40 micron absolute or less filter dewatering unit.

The permissible contamination limits are defined in terms of total contaminants; i.e., test fluid contaminants plus system hardware contaminants in the effluent from the system and determined by laboratory analysis.

a. Liquid Oxygen, Gaseous Nitrogen and Helium Systems, Permissible Contamination Limits by Gas Blowdown Test.

The contamination permitted entrapped on the filter pad of a blow horn (or equal) or in the test fluid effluent of a pressure bomb sample are as follows:

Hydrocarbon. - The filter pad will be inspected with black light. Fluorescence of fibers and solid particles which do not exceed the maximum size criteria will not be cause for system rejection. Fluorescence of filter pad stains or entrapped globules will be cause for further analysis for positive hydrocarbon determination. If the stains and/or globules are determined to be hydrocarbon the system will be rejected.

<u>Total Hydrocarbon</u>	25ppm by weight - increase in effluent over influent
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<u>Particle Distribution</u>	<u>Size, Micron</u>	<u>Number</u>
<u>Solid Particles</u>	Greater than 1000	0
<u>Fibers</u>	Greater than 6000 length	0

- b. RP-1 Fuel Systems. Permissible Contamination Limits. Criteria for Contamination Permitted in Effluents are as Follows:

<u>Particle Distribution</u>	<u>Size, Micron</u>	<u>Number</u>
<u>Solid Particles</u>	Greater than 1000	0
<u>Fibers</u>	Greater than 6000 length	0
<u>Water Content</u>	No increase in free water over RP-1 as delivered to system	

- c. Certification.

Each system which has been inspected in accordance with this specification shall be accompanied by evidence showing it meets cleanliness requirements. Evidence shall include the date of acceptance and the name or stamp of the responsible inspector.

5.0 CRITERIA FOR CONTROL OF PROPELLANTS AND SERVICE GASES.

This criteria governs the contamination permitted in the sample taken from missile fluids.

- a. Sampling:

- (1) Liquid Oxygen:

- (a) Transport Vehicle. - No sample analysis is required if the agency supplying the LOX delivers a certified laboratory report or acceptance tag with the liquid container showing that the appropriate military specification has been met. In these cases where liquids are off-loaded from rail cars or other storage vessels, a sample will be taken immediately after transferring and forwarded to a laboratory for compliance with the use limits in section 5b. No particle size check will be performed unless special justification is presented to the local ACO.
- (b) Launcher Storage Vessel - Sampling will be accomplished immediately after each fill operation and immediately after each Dual Propellant Loading (DPL). The criteria contained in the use limits will be used to judge the contamination permitted in samples taken.

- (2) Liquid Nitrogen: Same as 5a (1) (a) only.
- (3) RP-1 Fuel:
- (a) Transport Vehicle - No sample analysis is required if the agency supplying the RP-1 delivers a certified laboratory report or acceptance tag with a sealed fuel trailer showing the appropriate military specification that has been met. If the certified laboratory report or acceptance tag is missing, the fuel will be sampled for compliance with the use limits in section 5b. No particle check is required. All fuel must be transferred to the launcher storage vessel through a filter and dewatering unit.
 - (b) Launcher Storage Vessel (Atlas D and E, Titan I, R and D) - At each 30 day period a sample of fuel will be taken and checked for compliance with the use limits contained in 5b. Recirculation through the dewatering unit is mandatory at any time the water content exceeds criteria listed in 5b.
 - (c) Aboard Missile Storage (F Series) (Titan I) - Each time the missile is defueled or not to exceed six months, all RP-1 fuel will be circulated through the dewatering unit. At no time will fuel be transferred aboard the missile for storage if the total water content exceeds 15 PPM.
- (4) Service Gases - A sample may be taken for compliance with 5b.

b. Use Limits:

<u>Fluid</u>	<u>Hydrocarbon Content (PPM) (by Weight as Carbon)</u>	<u>PMM Acetylene Content</u>	<u>Purity</u>	<u>Dew Point at 1 Atmos- phere</u>	<u>Total Solids</u>
LO ₂	75	1.5	99.5%	-63.5°F	2.5 mg/liter
LN ₂	75	1.5	99.5%	-63.5°F	2.5 mg/liter
CO ₂	75	1.5	99.5%	-63.5°F	.01 mg/liter at S. T. P.
GN ₂	75	1.5	99.5%	-63.5°F	.01 mg/liter at S. T. P.
Helium	75	1.5	99.0%	-63.5°F	.01 mg/liter at S. T. P.
RP-1					1.5 mg/liter

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Water - There shall be no visible evidence of water.

API Gravity - Min. 42° . Max. 45° .

Flash Point - Min. 110°F .

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