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DESIGN OF GROUND LIFE SUPPORT SYSTEMS AND EQUIPMENT, STANDARD FOR

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ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CGA	Compressed Gas Association, Inc.
CO_2	carbon dioxide
DE	Engineering Development Directorate
GP	general publication
H_2O_2	hydrogen peroxide
IRFNA	inhibited-red-fuming nitric acid
ISBN	International Standard Book Number
JSC	Lyndon B. Johnson Space Center
kPa	kilopascal
KSC	John F. Kennedy Space Center
MIL	military
mm	millimeter
MMH	monomethylhydrazine
MSHA	Mine Safety and Health Administration
N_2H_4	hydrazine
N_2O_4	nitrogen tetroxide
NASA	National Aeronautics and Space Administration
NH_3	ammonia
NHB	NASA handbook
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
ppm	parts per million
SCUBA	self-contained underwater breathing apparatus
SM	standards manual
SPEC	specification
SR&QA	safety, reliability, and quality assurance
STD	standard
TLV	threshold limit value
UDMH	unsymmetrical dimethylhydrazine
°C	degree Celsius
°F	degree Fahrenheit

DESIGN OF GROUND LIFE SUPPORT SYSTEMS AND EQUIPMENT, STANDARD FOR

1. SCOPE

This standard, to be used in conjunction with SW-E-0002 and KSC-DE-512-SM, establishes basic mechanical design requirements for ground life support systems and equipment for use at KSC and other installations under KSC design responsibility. Requirements more stringent than those specified by this standard can be applied to a system at the discretion of the designer. This standard applies to new design only. National Institute for Occupational Safety and Health (NIOSH) approved equipment shall be exempted from the requirements of this standard.

1.1 Classification. - For the purpose of this standard, equipment shall be classified as follows.

1.1.1 Fixed Equipment. - Fixed equipment shall be designed to remain in place attached to permanent foundations.

1.1.2 Mobile Equipment. - Mobile equipment shall be designed to be moved from place to place on wheels, skids, specialized handling equipment, etc.

1.1.3 Portable Equipment. - Portable equipment shall be designed to be carried by one individual.

1.2 Use. - This standard covers life support equipment that may be used in one or more of the following environments:

a. Fuel vapors

(1) Hydrazine (N_2H_4)

(2) Monomethylhydrazine (MMH)

(3) Unsymmetrical dimethylhydrazine (UDMH)

(4) Aerozine 50

(5) Hydrogen

b. Oxidizer vapors

(1) Nitrogen tetroxide (N_2O_4)

(2) Inhibited-red-fuming nitric acid (IRFNA)

(3) Hydrogen peroxide (H_2O_2)

c. Smoke

All environments

d. Oxygen-deficient atmospheres

(1) Nitrogen-purged areas

(2) Partial vacuum

(3) Areas containing fire extinguishing agents [carbon dioxide (CO_2) Halon 1301, etc.]

e. Ammonia (NH_3)

1.3 Operating Media. - Life support systems covered by this standard shall use only one of the following operating media as applicable. Oxygen shall not be used in systems previously designed for air. Oxygen shall not be used with air-line respirators.

1.3.1 Gaseous Air. - Refer to CGA G-7.1, type 1, grade E, and SE-S-0073, table 6.3-29.

1.3.2 Gaseous Oxygen. - Refer to SE-S-0073, table 6.3-24.

1.3.3 Liquid Air.

1.3.3.1 Procurement Specification. - Refer to SE-S-0073, table 6.3-36.

1.3.3.2 Use. - Refer to CGA G-7.1, type II, grade B, at the user interface.

1.3.3.3 Use Limit. - Liquid air is an unstable mixture and, during use, its composition is constantly changing. The limiting values given in this standard are for the purpose of one-time acceptance of the liquid air for procurement only.

Changes in values subsequent to the procurement acceptance and prior to use in KSC life support equipment are controlled by use limits established by the design and operation activities. At KSC, liquid air use concentration shall not exceed 30 percent oxygen.

1.4 Function. - Life support systems covered by this standard provide service or protection for a user who will be

a. Working in a toxic or oxygen-deficient atmosphere

b. Escaping from a toxic or oxygen-deficient atmosphere

c. Resuscitating a victim of physical injury or of exposure to a toxic or oxygen-deficient atmosphere

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. When this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the Solicitation/Statement of Work/Contract.

2.1 Governmental.

2.1.1 Specifications.

John F. Kennedy Space Center (KSC), NASA

KSC-C-123	Surface Cleanliness of Fluid Systems, Specification for
KSC-SPEC-Z-0005	Brazing, Steel, Copper, Aluminum, Nickel, and Magnesium Alloys, Specification for
KSC-SPEC-Z-0008	Tube, Flared, Assemblies and Installation of Fittings and Fitting Assemblies, Fabrication and Installation of, Specification for
KSC-SPEC-Z-0019	Age Control of Elastomeric Parts, Specification for

KSC-SPEC-Z-0020	Welding of Aerospace Ground Support Equipment and Related Facilities

Lyndon B. Johnson Space Center (JSC), NASA

SE-S-0073	Space Shuttle Fluid Procurement and Use Control
SW-E-0002	Space Shuttle Ground Support Equipment General Design Requirements

Federal

GGG-M-125	Respirator and Respirator Assemblies: Air Line; Non-Powered Air Purifying and Powered Air-Purifying (General Specification)

Military

MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-C-7905	Cylinders, Steel, Compressed Gas, Non-Shatterable Seamless, 1800 PSI and 2100 PSI

2.1.2 Standards.

John F. Kennedy Space Center (KSC), NASA

KSC-STD-164	Environmental Test Methods for Ground Support Equipment, Standard for
KSC-STD-SF-0004	Ground Piping Systems Color Coding and Identification, Safety Standard for
KSC-STD-Z-0005	Pneumatic Ground-Support Equipment, Design of, Standard for

Military

MIL-STD-129	Marking for Shipment and Storage

MIL-STD-721	Definitions of Terms for Reliability and Maintainability
MIL-STD-889	Dissimilar Metals
MS33649	Bosses, Fluid Connection - Internal Straight Thread

2.1.3 Drawings.

John F. Kennedy Space Center (KSC), NASA

79K09560	Material Selection List for Liquid Oxygen Service
79K09561	Material Selection List for Gaseous-Oxygen and Air Service
79K11948	Material Selection List for Type J Fluid Service
79K14740	Material Usage Code
81K04331	Propellant Portable Containers, Marking of, Specification for

2.1.4 Publications.

National Aeronautics and Space Administration (NASA)

NHB 5300.4(1C)

John F. Kennedy Space Center (KSC), NASA

GP-435	Engineering Drafting Practices Manual, Volumes I and II
KSC-DE-512-SM	Facility, System, and Equipment General Design Requirements
KSC-DF-107	DE Technical Documentation Style Guide

KHB 5310.9	Kennedy Space Center Ground Systems Safety and Reliability Analyses

Federal

29 CFR 1910	Chapter XVII, Occupational Safety and Health Administration (OSHA), Department of Labor, Occupational Safety and Health Standards
42 CFR PART 84	Chapter I, Mine Safety and Health Administration (MSHA), Department of Labor, Respiratory Protective Devices
49 CFR 178.37	Specification 3AA Seamless Steel Cylinders Made of Definitely Prescribed Steels or 3AAX; Seamless Steel Cylinders Made of Definitely Prescribed Steels of Capacity Over 1,000 Pounds Water Volume

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

2.2 Non-Governmental.

American Conference of Government Industrial Hygienists (ACGIH)

ISBN 0-936712-XX-X	TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment

(Application for copies should be addressed to the Publications Office, ACGIH, 6500 Glenway Avenue, Building D-5, Cincinnati, OH 45211.)

American National Standards Institute (ANSI)

ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
ANSI B40.1	Gauges, Pressure, Indicating Dial Type - Elastic Element

ANSI B46.1	Surface Texture (Surface Roughness, Waviness, and Lay)

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

American Society of Mechanical Engineers (ASME)

ASME Code	Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2

(Application for copies should be addressed to the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.)

Compressed Gas Association, Inc. (CGA)

CGA G-7.1	Commodity Specification for Air

(Applicaton for copies should be addressed to Compressed Gas Association, Inc., 1725 Jefferson Davis Highway, Suite 1004, Arlington VA 22202-4102.)

3. REQUIREMENTS

3.1 Design.

3.1.1 Occupational Safety and Health Administration (OSHA) Requirements. - Design shall comply with 29 CFR 1910 and 42 CFR Part 84.

3.1.2 Design Safety Factor. - For portable equipment, design shall comply with the requirements of 49 CFR (DOT). Fixed systems shall conform to the requirements of the ASME code, Section VIII, Division 1 or Division 2. Fixed piping and tubing systems shall conform to the requirements of ANSI B31.3.

3.1.3 Interior Surface Finish. - Interior surface roughness, except for pressure vessels, shall not exceed the No. 63 finish specified in ANSI B46.1.

3.1.4 Exterior Surface Finish. - Exterior surfaces shall be corrosion resistant in accordance with KSC-STD-164 and shall be free of burrs or sharp edges.

3.1.5 Interchangeability. - All identical parts and assemblies shall be directly and completely interchangeable as specified in MIL-STD-721.

3.1.6 Provisions for Adjustment and Recalibration. - Provision for adjustment and recalibration shall be incorporated in the design to compensate for normal wear and use.

3.1.7 Interference Fitting. - Interference fitting (e.g., press fit or shrink fit) shall not be employed.

3.1.8 Welding. - Welding shall comply with KSC-SPEC-Z-0020 as applicable. Automatic welding shall comply with KSC-SPEC-Z-0020.

3.1.9 Brazing. - Brazing shall comply with KSC-SPEC-Z-0005.

3.1.10 Soldering. - Soldering shall not be used.

3.1.11 Gluing and Bonding. - Gluing and bonding adhesives shall not be applied to metals except for surface labels and seals.

3.1.12 Anodizing. - Anodizing of aluminum shall comply with MIL-A-8625.

3.1.13 Painting. - Paint shall not be applied to interior surfaces.

3.1.14 Cleaning. - All interior surfaces shall be cleaned to KSC-C-123, level 300A.

3.1.15 Materials.

3.1.15.1 Dissimilar Metals. - The use of dissimilar metals shall comply with MIL-STD-889 and KSC-SPEC-Z-0020.

3.1.15.2 Corrosion Resistance. - Metals that do not meet the applicable test requirements of KSC-STD-164 for corrosion resistance to salt fog shall not be used.

3.1.15.3 Gaseous Oxygen and Breathing Air Compatibility. - All materials in contact with the breathing media shall comply with 79K09561 as applicable.

3.1.15.4 Liquid Oxygen and Liquid Air. - All materials in contact with liquid oxygen or liquid air shall comply with 79K09560 as applicable.

3.1.15.5 Age Control of Soft Goods. - When age control of elastomers is considered to be a necessary design requirement, such control shall comply with KSC-SPEC-Z-0019.

3.1.15.6 Fungus Resistance. - Materials that provide nutrient for fungus shall not be used.

3.1.15.7 Hazardous Environment Compatibility. - All materials that may come in contact with ammonia, N_2O_4, N_2H_4, MMH, UDMH, Aerozine 50, gaseous hydrogen, or liquid hydrogen shall comply with 79K11948 as applicable. All materials in contact with liquid oxygen shall comply with 79K09560. Materials in contact with other hazardous environments shall be tested for compatibility prior to their use.

3.1.16 Allowable Leakage. - Allowable leakage for portable-gaseous-air or portable-gaseous-oxygen supply systems is defined as follows:

a. Leakage shall not exceed 4×10^{-3} percent of usable compressed-cylinder volume per hour with the primary shutoff valve closed.

b. For components between the primary shutoff valve and second-stage regulator (or resuscitator head), leakage shall not exceed 0.16 percent of the cylinder volume with primary shutoff valve open and second-stage regulator closed.

3.1.16.1 Allowable Reverse Leakage. - Allowable reverse leakage of hazardous vapors through a face mask seal shall not exceed the total threshold limit value (TLV) for chemical substances as specified in ISBN 0-936712.

3.1.17 Allowable Permeability. - Allowable permeability of hazardous fluids or vapors for protective clothing and equipment shall not exceed the total TLV for chemical substances as specified in ISBN 0-936712.

3.2 Components.

3.2.1 Pressure Vessels. - Portable pressure vessels shall conform to 49 CFR 178.37. Where lightweight pressure vessels are specified, they shall instead conform to the performance requirements of MIL-C-7905, paragraph 3.6. All portable pressure vessels shall be marked and color coded as specified in 81K04331. Permanently installed pressure vessels shall be marked and color coded as specified in KSC-STD-SF-0004 and shall conform to the requirements of KSC-STD-Z-0005.

3.2.2 Fusible Plug/Burst Disc Assembly. - A fusible plug/burst disc assembly, venting to atmosphere, shall be incorporated when a portable pressure vessel is used. There shall be no functional components (e.g., regulator, filter, etc.) installed between the pressure vessel and the assembly. The fusible plug/burst disc assembly shall comply with the following requirements.

a. The burst disc shall burst at the pressure vessel's maximum allowable working pressure plus 10 to 30 percent.

b. The fusible plug shall melt at 98 to 105 degrees Celsius (°C) [208 to 220 degrees Fahrenheit (°F)]

c. The discharge flow rate, upon rupture of the burst disc, shall not be less than the flow rate of the nearest downstream relief valve.

d. The configuration shall be designed to prevent impingement of the discharge gas on adjacent parts or on operating personnel.

e. The fusible plug/burst disc assembly shall be accessible for easy removal and replacement.

3.2.3 Flexible Hose. - Flexible hoses shall meet the following requirements:

a. End fittings shall be permanently attached.

b. Reinforcing braid (metal or fabric) shall be incorporated.

c. The outer covering shall be abrasion resistant and shall leave no visible marks when dragged over a rough surface (e.g., cement).

d. Flexibility shall conform to specific operational requirements.

e. Cleanliness shall be in accordance with KSC-C-123 level 300A.

3.2.4 Flexible Tube. - Flexible tubes shall not be used.

3.2.5 Filters. - A 10- to 30-micron (absolute rating) filter shall be incorporated upstream of each pressure regulator.

3.2.6 Quick-Disconnect Couplings. - All quick-disconnect couplings shall conform to the following requirements:

a. Seats and seals shall be nonmetallic and shall be replaceable.

b. Both halves shall incorporate automatic closure upon separation.

c. Air-line couplings shall be incompatible with facility outlets of other gas systems to prevent inadvertent connection of airline respirators with nonrespirable gases or oxygen.

d. Breathing air systems quick-disconnect couplings used at KSC or Cape Canaveral Air Station shall be a 9.5-millimeter (mm) (3/8-inch) Hansen or equal (except systems that interface with astronaut suit or rescue equipment; these systems shall comply with item C).

3.2.7 Pressure Regulator. - A pressure regulator shall be installed where reduced pressure is needed. The reduced pressure shall not be provided by an orifice or filter. The pressure regulator shall comply with the following requirements:

a. The pressure reduction (outlet) shall not be less than 2 percent of the supply pressure (inlet) for a one-stage regulator.

b. The accuracy of the pressure regulator shall be within 10 percent of its specified setting throughout the entire specified pressure supply (inlet) range.

c. The pressure regulator shall be designed to fail safely in the closed position without damage to any of the other components in the system.

3.2.8 Valves.

3.2.8.1 Shutoff (Hand) Valves. - Valves shall be globe or needle (metering) type and shall comply with the following requirements:

a. The valve stem seal shall not be subjected to supply pressure when the valve is in the closed position.

b. Seats shall be the replaceable nonmetallic type.

c. The valve shall be designed and constructed to prevent removal of the stem from the valve body during normal use to avoid sudden release of the full pressure of the container when the valve is opened.

3.2.8.2 Check Valves. - All check valves shall be spring loaded and shall have replaceable nonmetallic seats.

3.2.8.3 Relief Valves. - There shall be a relief valve immediately downstream of each pressure regulator. The relief valve flow capacity shall not be less than the full-open flow capacity of the regulator. All relief valves, except for inhalation and exhalation valves, shall conform to the following requirements.

a. The spring shall be outside of the fluid flow path.

b. Seats shall be the replaceable nonmetallic type.

3.2.8.4 Inhalation Valves. - Inhalation valves shall be protected against distortion and accidental damage.

3.2.8.5 Exhalation Valves. - Exhalation valves shall be designed and constructed to prevent inward leakage of contaminated air to the extent that the air or oxygen inside the face mask or full facepiece remains within specification requirements.

3.2.9 Face Mask. - A face mask used for medical purposes (e.g., on a resuscitator) shall be transparent to permit viewing of the mouth and nasal passages.

3.2.10 Full Facepiece. - A full facepiece (i.e., used to cover the entire face and provide panoramic vision) shall comply with GGG-M-125, paragraphs 3.6, 3.7.2.1.2, and 3.7.2.2.

3.2.11 Head Harness.

3.2.11.1 Flexible. - A flexible head harness attached to a face mask or full facepiece shall comply with the following requirements:

a. Provide adequate tension for sealing purposes.

b. Provide evenly distributed pressure over the area of contact between the face mask (or full facepiece) and the face.

c. Provide elasticity for at least partial self-adjustment.

d. Provide for easy detachment from the face mask (or full facepiece) and subsequent reattachment.

3.2.11.2 Rigid. - A rigid head harness attached to a face mask or full facepiece shall comply with the following requirements.

a. Provide adequate tension for sealing purposes.

b. Provide evenly distributed pressure over the area of contract between the face mask (or full facepiece) and the face.

c. Provide adjustment features for widely varying head sizes and shapes.

d. Provide quick-don capability of face mask (or full facepiece) to the face.

3.2.12 Carrying Case. - When a carrying case is used, it shall comply with the following requirements.

a. Hold all items firmly in place when oriented in any position.

b. Protect items from damage when dropped in any orientation from a height of 1.5 meters (5 feet) onto a concrete floor.

3.2.13 Instrumentation.

3.2.13.1 Pressure Gages. - A pressure gage shall be installed on all pneumatic supply sources with the following additional requirements.

3.2.13.1.1 Fixed and Mobile Equipment. - Gages shall conform to ANSI B40.1 and shall be installed before and after each regulator.

3.2.13.1.2 Portable Equipment. - Gages shall conform to 42 CFR, Part 84, and shall be of the dial type.

3.2.13.2 Flowmeters. - Flowmeters shall be the volumetric measuring type with an accuracy of plus or minus 5 percent of reading.

3.2.13.3 Warning Devices. - Warning devices shall be of the audible type as specified in 29 CFR 1910.134. In areas subject to high noise levels where hearing protection is required and where remote compressor equipment cannot be heard, additional visual warning devices (lights) shall be installed.

3.2.13.3.1 Fixed and Mobile Equipment. - An end-of-service-life (depletion of operating media) warning device shall be installed on all pneumatic supply sources. Warning devices shall be installed on compressor systems to indicate the following failures:

a. Compressor failure

b. Compressor overheating

c. Carbon monoxide over 10 parts per million (ppm)

d. Oxygen concentration under 19.5 percent

Oxygen and carbon monoxide sample ports shall be located within the first 1 meter (3 feet) of piping exiting the compressor. Compressor failure and compressor overheating sensors shall be installed on the compressor.

3.2.13.3.2 Portable Equipment. - With the exclusion of medical resuscitators and self-contained underwater breathing apparatus (SCUBA) systems, an end-of-service-life, audible warning device shall be used on all equipment not exclusively used for escape purposes. The device shall comply with the following additional requirements:

a. The device shall indicate a minimum of 25 plus or minus 5 percent remaining useful life. If air or oxygen is vented to the atmosphere as a result of the operation of the warning device, the venting shall be taken into account when computing the 25 plus or minus 5 percent remaining useful life.

b. The device shall be operable in any orientation.

c. The device shall produce 75 to 85 decibels when intended for use in other than a quiet environment (e.g., a hospital room). When intended for use in a quiet environment, it shall produce 50 to 60 decibels.

3.3 Threaded Pressure Ports. - Threaded pressure connectors shall conform to MS33649.

3.4 Tubing and Tube Fittings.

3.4.1 Fixed Installations. - System design shall be in accordance with KSC-STD-Z-0005. Tubing and tube fittings shall be installed in accordance with KSC-SPEC-Z-0008.

3.4.2 Mobile Equipment. - Tubing and tube fittings shall be installed in accordance with KSC-SPEC-Z-0008.

3.4.3 Portable Equipment. - Tubing or pipe fittings shall be standard commercial products of domestic manufacture.

3.5 Design Documentation.

3.5.1 Specifications. - Detailed design specifications shall comply with the requirements of KSC-DE-512-SM or SW-E-0002 as applicable.

3.5.2 Drawings. - Detailed design drawings shall be prepared in accordance with the requirements of GP-435 as applicable. Drawings shall include flow schematics and illustrated assembly views. All internal parts shall be identified as to order of assembly, official nomenclature, part number, and material makeup. All systems containing a breathing media shall, in addition, have all their parts coded on the drawing parts list in accordance with 79K14740.

3.5.3 Manuals. - Technical manuals shall be prepared in accordance with the requirements of KSC-DF-107.

3.5.4 Federal Stock Numbers. - Components, parts, O-rings, etc., shall be designated by Federal stock number when available.

4. QUALITY ASSURANCE PROVISIONS

4.1 Design and Development Controls. - The designer shall implement the following as applicable to ensure design integrity:

a. Conformance inspection and qualification test requirements for components and end items (including specific nondestructive testing methods, test equipment, environmental conditions, and sample size)

b. Identification and data retrieval requirements

c. Proper specification of all hardware

d. Performance and tolerance limits

e. Generation of required drawings, specifications, standards, and procedures

f. Service life requirements

g. Acceptance/rejection criteria

h. Handling, storage, preservation, marking, labeling, packaging, and shipping requirements

i. Designation of critical equipment to be placed under integrity control

j. Recommendation of spare parts or components based on their system criticalness, procurement lead time, and KSC cycle life

4.2 Safety, Reliability, and Quality Assurance (SR&QA) and Maintainability Analysis. - SR&QA and maintainability analysis shall be as specified in KHB 5310.9.

4.3 Contractual Requirements. - When this standard is referenced in a contract, the statement of work shall invoke the applicable provisions of NHB 5300.4(1C).

5. PREPARATION FOR DELIVERY

5.1 Cleanliness. - Internal cleanliness of fluids systems shall meet or exceed KSC-C-123, level 300A initially. From that point, systems will be maintained visually clean as defined by the respirator manufacturer or sustaining engineering.

5.2 Pressurization. - Fluid systems shall be pressurized to 138 kilopascal (kPa) plus or minus 35 kPa (20 plus or minus 5 pounds per square inch) gage with gaseous air in accordance with CGA G-7.1 type 1, grade E, to prevent intrusion of contaminants.

5.3 Packing and Marking for Shipment. - Items to be shipped shall be securely packaged in appropriate shipping containers that will provide complete protection against damage or degradation during shipping. All applicable carrier rules shall be complied with. Containers shall be marked to conform to MIL-STD-129.

6. NOTES

6.1 Intended Use. - This standard is intended for use in the design of life support equipment used for astronaut rescue, toxic propellant handling, fire rescue, emergency escape, and the performance of normal work while in a hazardous environment per 1.2. NIOSH-approved equipment is exempt from the requirements of this standard.

NOTICE. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner

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