

CRYOGEN SAFETY

NIST S 7101.52

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1. PURPOSE

The purpose of this suborder is to establish requirements, associated roles and responsibilities, and guidance to enable employees to work safely with or around cryogenes.

2. BACKGROUND

None.

3. APPLICABILITY

- a. This suborder is limited to the use of liquid helium, liquid nitrogen, liquid neon, and liquid argon and the liquid-to-vapor transition. Since oxygen has the potential to condense, accumulate, and drip from transfer lines when liquid cryogenes with normal boiling points lower than that of oxygen are being transferred, and thereby pose a risk of explosion or fire, its properties are included in this document for reference. Other cryogenes such as liquid hydrogen, liquid ammonia, and numerous other refrigerants may pose hazards that require significantly different controls from those described in this Cryogen Safety suborder. The use of cryogenes other than helium, nitrogen, neon and argon should be brought to the attention of line management for additional review.
- b. The requirements related to bulk cryogen storage tanks (BCST) apply to NIST sites for which NIST has jurisdiction, custody, and control. If NIST work at sites for which NIST does not have jurisdiction, custody, and control requires the installation of a BCST, the OU responsible shall work with the authorities at that site to ensure the appropriate safety requirements indicated in Section 6.c(7) are met or equivalent protection is provided.

¹ For revision history, see Appendix A.

35 **4. REFERENCES**

- 36 a. ASME Boiler and Pressure Vessel Code Section VIII, Division 1.
37
38 b. ANSI/ASME B31.1, Power Piping.
39
40 c. ANSI/ASME B31.3, Process Piping.
41
42 d. CGA P-12, Safe Handling of Cryogenic Liquids.
43
44 e. NFPA 45, Fire Protection for Laboratories Using Chemicals.
45
46 f. NFPA 55, Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic
47 Fluids in Portable and Stationary Containers, Cylinders, and Tanks.
48

49
50 **5. APPLICABLE NIST OCCUPATIONAL SAFETY AND HEALTH SUBORDERS**

- 51 a. NIST S 7101.20: *Work and Worker Authorization Based on Hazard Reviews*;
52
53 b. NIST S 7101.21: *Personal Protective Equipment (PPE)*;
54
55 c. NIST S 7101.22: *Hazard Signage*;
56
57 d. NIST S 7101.23: *Safety Education and Training*;
58
59 e. NIST S 7101.59: *Chemical Hazard Communication*;
60
61 f. NIST S 7101.60: *Chemical Management*; and
62
63 g. NIST S 7101.61: *Compressed Gas Safety*.
64

65
66 **6. REQUIREMENTS**

- 67 a. General
68
69 (1) The OUs shall manage cryogenic hazards in accordance with NIST S 7101.20: *Work and*
70 *Worker Authorization Based on Hazard Reviews*, their OU implementations thereof, and
71 the requirements of this suborder.
72

73 b. Hazard Analysis

74

75 (1) The hazard analysis process shall encompass cryogenic hazards in all areas where
76 cryogenics are used and stored.

77

78 (2) Oxygen-deficiency/oxygen-enrichment hazard assessments must be done as part of the
79 hazard review before beginning any cryogenic experiments.

80

81 (a) The OU shall ensure calculations to determine the need for an oxygen monitor are
82 performed.²

83

84 i. The OU may perform the calculations themselves or they may request the
85 assistance of another person with the appropriate knowledge to do so (*e.g.*,
86 another cryogen user or the Cryogen Safety Program Manager).

87

88 ii. The OU shall ensure the calculations are verified by a second person with the
89 appropriate knowledge to do so, unless the Cryogen Safety Program Manager
90 performs the first set of calculations for them.

91

92 Should the calculations performed by the OU indicate the need for an oxygen monitor,
93 the Cryogen Safety Program Manager shall verify the calculations to ensure a possible
94 oxygen-deficiency/oxygen-enrichment hazard, unless the Cryogen Safety Program
95 Manager performed the first set of calculations.

96

97 c. Hazard Control

98

99 (1) Appropriate control measures shall be selected, documented, and implemented.

100

101 (2) Cryogen handling is not permitted in laboratories without adequate ventilation, or, if
102 ventilation is inadequate or non-existent, without additional applied controls that reduce
103 the risk of exposure of personnel to an ODH to an acceptable level.

104

105 (3) Hazard signage that is in accordance with NIST S 7101.22: *Hazard Signage* shall be
106 posted at every entrance to every space that may have an ODH hazard. Example signs

² There are several acceptable methods of determining the risk of oxygen-deficiency hazards (ODH) available through the Cryogen Safety Program webpage on the NIST safety website. Appendix B of this suborder lists physical characteristics of the most common cryogenics, including expansion ratios, which are critical in calculating oxygen-deficiency hazards. Where characteristics are affected by atmospheric pressure, different values are listed for Boulder, CO, and Gaithersburg, MD.

107 are presented in Appendix C of this suborder. The hazard review shall identify the level
108 of hazard, so that the appropriate signal word can be selected for the sign(s). See Section
109 7: Definitions of this suborder for a description of the various signal words. In most
110 cases, the signal word will either be “DANGER” or “WARNING”.

111
112 (4) When a laboratory cannot reduce the risk of exposure of personnel to an ODH to an
113 acceptable level (normally $\geq 19.5\%$ oxygen), the hazard review shall ensure that an
114 oxygen monitor is used. A fixed oxygen monitor shall have an audible alarm, warning
115 light, and a digital readout. Personal monitors may also be used or required depending
116 on the risk.

117
118 (a) Oxygen monitors shall be installed, used, maintained, and calibrated according to
119 manufacturers’ recommendations.

120
121 (b) Calibration and maintenance records shall be kept with or near the monitor.

122
123 (c) The hazard review should consider the need to tie the alarm to a central fire alarm
124 system. This may be appropriate in cases where the potential ODH may affect spaces
125 beyond a single laboratory or single room.

126
127 i. The NIST Authority Having Jurisdiction (AHJ) shall be notified if there is a
128 request to tie the oxygen monitor into the NIST fire alarm system such that the
129 NIST AHJ can approve or disapprove the tie in. If approved, the NIST AHJ
130 shall witness its installation.

131
132 (5) Cryogen containers that are appropriate for the experiment design, facility, and research
133 activity shall be selected during the hazard review.

134
135 (a) Glass dewars and cryostats can be used only after they have been specifically
136 addressed in the applicable hazard review.

137
138 (b) Appropriate styrofoam containers are permitted for the temporary storage of small
139 amounts of LN₂ if allowed by the hazard review.

140
141 (c) Regular thermos bottles are not permitted for storing liquid cryogens even for short
142 periods of time.

143
144 (d) Non-pressurized storage dewars shall not be pressurized or modified to be pressurized
145 as these containers are not designed to withstand pressure.

146

- 147 (e) Hazard reviews shall be conducted before any dewar is modified and subsequently
148 used. All potentially impacted personnel, including storeroom personnel who fill the
149 dewar, shall be included in the hazard review process and/or informed of its results.
150
- 151 (f) Changes to dewars shall be accomplished by the addition of plumbing or hardware
152 where practical and technically appropriate, rather than the removal of existing
153 hardware and substituting new.
154
- 155 (g) Adequate pressure-relief devices must be provided throughout the cryogen system to
156 prevent high-pressure gas build-up as the liquid evaporates. For example, a cryostat
157 should have redundant fill tubes or, if not, a burst disk on the vacuum space.
158 Basically, there should always be at least two relief paths for a liquid-containing
159 vessel. This issue needs to be dealt with on a case-by-case basis as part of the hazard
160 review.
161
- 162 (h) Cryogenic systems that are designed, fabricated, or modified in-house shall be
163 designed to withstand pressures of at least 150% of the maximum pressure relief on
164 the system.
165
- 166 (i) Calculations of the proper relief valve size and pressure drop shall be included in the
167 hazard review for any cryogen system that is to be designed, fabricated, or modified
168 in-house.
169
- 170 (j) If feasible, existing equipment, systems, and operations shall be brought into
171 compliance with current standards. The safety aspects related to any exceptions to
172 current standards shall be reviewed in detail and documented, and further operation
173 shall be contingent on OU Director's approval.
174
- 175 (k) Maintenance and inspection requirements for dewars, cryostats, and cryogenic
176 systems shall be developed during the hazard review process and included in the
177 Standard Operating Procedures (SOPs). At a minimum, an initial inspection of the
178 equipment by a trained cryogen user should be conducted before equipment is put
179 into operation.
180
- 181 (l) A plan for testing pressure relief devices on cryogenic systems, in accordance with
182 the manufacturer's or installer's recommendations, shall be included in the hazard
183 review for the system.

184 (6) Transport

185

186 (a) To transport a dewar between floors, use an elevator. Small amounts of cryogen in
187 non-pressurized containers may be carried on stairs with extreme caution and shall be
188 assessed in the OU on a case-by-case basis. Due to the risk of an Oxygen Deficiency
189 Hazard, no one may accompany a dewar in an elevator. Depending on the elevator
190 this may require two people (one at the sending floor and one at the receiving floor),
191 and signage prohibiting anyone from riding the elevator with the dewar. An example
192 sign is included in Appendix C of this suborder. If an elevator allows manual
193 operation using a key, transport may be accomplished without a person at the
194 receiving floor as the elevator will remain in the manual mode (preventing use by
195 other people) until the operator with the key arrives to remove the dewar and switch it
196 out of manual mode. Signage prohibiting anyone from entering the elevator is
197 recommended in the manual mode.

198

199 (b) Transporting cryogens in vehicles shall only be done by personnel who work in the
200 storeroom, shipping and receiving, a laboratory, or by a contract supplier, and the
201 personnel shall be specifically trained in the proper transport of cryogens. All
202 transports of cryogens must occur in open vehicles, such as pickups or flatbed trucks,
203 and the dewars being transported must be secured. Wheel brakes, if present on the
204 dewar, must be locked.

205

206 (7) Bulk Cryogen Storage Tanks (BCST)

207

208 (a) OSHE shall maintain an inventory of all bulk cryogen storage tanks (BCSTs) located
209 on NIST sites for which NIST has jurisdiction, custody, and control.

210

211 i. This inventory shall be reviewed annually by the Program Manager for
212 Cryogen Safety.

213

214 (b) The OU responsible for each BCST shall assign an individual to act as the OU Point
215 of Contact (PoC) for the BCST.

216

217 i. The OU PoC shall facilitate communications between the NIST Contracting
218 Officer Representative (COR), the cryogen supply contractor, the OU, and all
219 cryogen users served by the BCST.

220

221 (c) All new BCSTs shall be designed and constructed in accordance with all applicable
222 standards and state-of-the-art industry practices.

223

- 224 i. The Fire & Facilities Safety Group, OSHE, shall review all technical plans for
225 the proposed installation of a BCST.
- 226
- 227 ii. Prior to BCST installation, the contractor shall provide a job-specific safety
228 and health plan for the installation. This plan shall be approved by OFPM and
229 the OSHE prior to beginning the execution of the project.
- 230

231 (d) Physical security for BCSTs

- 232
- 233 i. Each BCST shall be provided with physical security to protect the tank from
234 vehicular traffic and other sources of physical impact or damage, to include
235 but not be limited to the use of:
 - 236
 - 237 (i) Bollards designed for this purpose;
 - 238 (ii) Curbs;
 - 239 (iii) Jersey barriers; and/or
 - 240 (iv) Other traffic control devices.
- 241
- 242 ii. For BCSTs located on an unsecured site, the physical security shall also
243 prevent access to the tank and its associated systems by unauthorized
244 personnel through means such as:
 - 245
 - 246 (i) Fences;
 - 247 (ii) Locked gates; and
 - 248 (iii) Other equivalent features.
- 249

250 (e) Signage for BCST

- 251
- 252 i. Each BCST shall have a Point-of-Contact sign indicating the OU point of
253 contact (PoC) for the tank, including, but not limited to:
 - 254
 - 255 (i) NIST staff member name(s) and on-campus telephone number(s);
 - 256 (ii) OU, division, group name;
 - 257 (iii) After hours contact(s) name and contact telephone number(s); and
 - 258 (iv) NIST Emergency telephone number corresponding to the campus.
- 259
- 260 ii. Each BCST shall have a hazard sign (please see Appendix C):
 - 261
 - 262 (i) Compliant with NIST S 7101.20: *Hazard Signage*;

- 263 (ii) In accordance with Compressed Gas Association standards CGA C-7;
264 and
265 (iii) Using the signal word “Warning” with an orange background.
266
- 267 iii. Each BCST shall have an NFPA “diamond” hazard identification system
268 diagram.
- 269
- 270 (i) In accordance with Compressed Gas Association standards CGA P-19,
271 liquid nitrogen, liquid argon, and liquid carbon dioxide shall have hazard
272 ratings of 3-0-0-SA.
273
- 274 iv. Each BCST on the Gaithersburg campus shall have an emergency “Notice”
275 sign with the phone number for the Gaithersburg Fire Protection Group
276 (please see Appendix C).
277
- 278 v. All signs shall be:
279
- 280 (i) Large enough to be read at a safe distance from the BCST;
281 (ii) Weatherproof; and
282 (iii) Secured to the supporting surface so that they cannot be removed or
283 disturbed by the elements or other physical forces.
284
- 285 (f) Routine In-service Inspections
286
- 287 i. The OU PoC shall perform a visual inspection of each BCST at least monthly.
288 The inspection form found in Appendix D, or the equivalent, may be used to
289 document this effort.
290
- 291 ii. The inspection shall include a visual inspection of the tank's:
292
- 293 (i) Exterior surfaces;
294 (ii) Physical security measures; and
295 (iii) Signage.
296
- 297 iii. Evidence of the following shall be documented and reported to the OU’s
298 Safety Program Coordinator or appropriate Group Leader and the COR for the
299 bulk cryogen delivery contract:
300
- 301 (i) Leaks;
302 (ii) Shell distortions;

- 303 (iii) Signs of settlement, i.e, any visible sign that the tank has shifted to a
- 304 lower position than in the past;
- 305 (iv) Corrosion;
- 306 (v) Poor condition of the foundation, paint coatings, insulation systems, and
- 307 appurtenances; and
- 308 (vi) Other potential damage.
- 309
- 310 iv. All conditions requiring corrective actions shall be reported to the inspector's
- 311 Supervisor and shall be addressed by the OU responsible for the tank. The
- 312 bulk cryogen contractor shall be notified of the required corrective action(s) in
- 313 cases where they are responsible for maintenance of the tank.
- 314
- 315 v. Each inspection shall be recorded and retained for at least five years by the
- 316 OU PoC.
- 317

318 (g) Contractor-Provided Services

319 The contractor hired to provide bulk cryogenics shall provide the following safety-

320 related services as part of their contract.

321

- 322 i. The contractor shall provide a job-specific safety and health plan that has been
- 323 approved by the COR and OSHE prior to beginning the execution of the
- 324 contract.
- 325

- 326 ii. Annual Inspections
- 327

- 328 (i) The contractor shall conduct an annual inspection of all tanks covered by
- 329 the contract, NIST-owned and contractor-owned.
- 330 (ii) The contractor shall inspect the tanks using American Petroleum
- 331 Institute (API) Standard 653, *Tank Inspection, Repair, Alteration, and*
- 332 *Reconstruction*.
- 333 (iii) Each inspection record shall be retained for at least five years by the OU
- 334 PoC.
- 335

- 336 iii. The contractor shall replace all pressure relief safeties at least once every five
- 337 years.
- 338

339 (h) All modifications and repairs of existing tanks shall be designed and constructed in

340 accordance with all applicable standards and state-of-the-art industry practices.

341

- 342 i. Prior to tank modification or repair, the contractor shall provide a job-specific
343 safety and health plan for the work to be performed. This plan shall be
344 approved by OFPM and the OSHE prior to beginning the execution of the
345 project.
346
- 347 ii. Each modification or repair shall be documented and retained for the life of
348 the tank by the OU PoC.
349
- 350 (8) The hazard review or associated SOPs shall describe the required controls to minimize
351 the risks, in accordance with the requirements of NIST S 7101.60: *Chemical*
352 *Management*.
353
- 354 (a) Safe work practices to minimize the risk of cryogen contact, based on how the
355 cryogen is being used, shall be listed in SOPs. An OU or Division may choose to
356 adopt a set list of safe work practices, such as the cryogen tool titled *Short List of*
357 *Proper Cryogen Handling Practices*, in order to avoid repetition in multiple hazard
358 reviews and/or SOPs.
359
- 360 (9) Personal protection equipment (PPE) assessments for the use of cryogens shall be
361 completed as part of the hazard review and in accordance with the NIST S 7101.21:
362 *Personal Protective Equipment*. Some well-defined and controlled tasks may require less
363 PPE, and some operations may need to balance the need for dexterity with PPE
364 requirements. To accommodate these needs, the PPE requirements may be reduced when
365 the reason is documented as part of an approved SOP and hazard review.
366
- 367 (a) When pouring cryogens from hand-held dewars or transferring liquid cryogens from
368 low-pressure pressurized storage dewars, the following shall be required:
369
- 370 i. Eye protection that provides at least as much protection as safety glasses with
371 side shields;
372
- 373 ii. Closed toe shoes;
374
- 375 iii. Gloves whenever there is risk of exposure to liquid cryogen, cold gas, or cold
376 surfaces, except when the loss of dexterity would present a greater risk.
377 Either approved cryogenic gloves or oil-free leather gloves must be used, and
378 they should be loose enough to allow for rapid removal;
379
- 380 iv. Protective clothing when there is risk of exposure to the liquid cryogen, such
381 as when transferring from a storage dewar into a smaller cryostat. Either a

382 cryogenic apron or a lab coat with no pockets (to prevent trapping the liquid)
383 should be worn. Clothing should be reviewed for its potential to trap the
384 cryogen before transfer is made; and

385
386 v. Protective clothing when there is a risk of exposure to cold gas during cryogen
387 transfer and when wearing the protective clothing would not present a greater
388 hazard. Simple coverage is often sufficient.

389
390 (b) When transferring cryogens from high-pressure pressurized storage dewars, the PPE
391 required must be specified in the hazard review for each specific experiment.

392
393 (10) Avoid ingestion or inhalation of cryogenic liquid or gas. Under no circumstances
394 should liquid cryogen be put in the mouth as a demonstration, even in small quantities.

395
396 (11) Chemical Inventory and Hazard Communication

397
398 (a) Cryogen containers shall be inventoried in accordance with the requirements of NIST
399 S 7101.59: *Chemical Hazard Communication*:

400
401 i. Each large (e.g., 100 – 240 liter) pressurized cryogen storage container must
402 be entered into NIST’s hazardous chemical inventory database; and

403
404 ii. Chemical labeling shall be in accordance with the requirements of NIST S
405 7101.59, and specifically, must be placed on the container without obscuring
406 any other label information.

407
408 (b) Hazards associated with cryogens shall be communicated in accordance with the
409 requirements of the NIST S 7101.59: *Chemical Hazard Communication*.

410
411 i. Door signage shall comply with the requirements of NIST S 7101.22: *Hazard*
412 *Signage* (Appendix C contains sample hazard signage for ODH); and

413
414 ii. The hazardous chemical inventory that lists chemicals by their product
415 identifiers that appear on the associated container labels and Safety Data
416 Sheets (SDSs) for each work area shall be updated as necessary.

417
418 (12) Training

419
420 (a) Training developed by the OSHA Cryogen Safety Program Manager and the OUs
421 shall be in accordance with the requirements of the NIST S 7101.23: *Safety Education*

422 *and Training* and made available for use by employees. The training should include
423 topics such as the following, as appropriate:

- 424
- 425 i. Properties of cryogens in their liquid and gas states;
- 426
- 427 ii. Safe operation of equipment being used with cryogens (*i.e.*, location and
428 function of valves, pressure reading devices, safety devices, inspections, *etc.*);
- 429
- 430 iii. Equipment hazards/failure modes;
- 431
- 432 iv. Oxygen deficiency risk assessments where cryogens are being used;
- 433
- 434 v. Materials compatible with cryogens (if relevant to the task);
- 435
- 436 vi. Location and use of personal protective equipment (PPE);
- 437
- 438 vii. Emergency response; and
- 439
- 440 viii. Situations that cause cryo-pumping and formation of an ice blockage; ice
441 blockage identification; and ice blockage removal techniques or resources.
- 442

443 (b) Training shall be provided by the OU to all cryogen users and transporters during their
444 initial assignment and it shall include hands-on training.

- 445
- 446 i. Refresher training shall be provided by the OU when it is apparent the
447 cryogen user or transport would benefit from such training.
- 448

449 (13) Emergency Procedures

450

451 (a) The hazard review shall include emergency procedures for the laboratories.

452

453 (b) Situations warranting consideration as appropriate include:

- 454
- 455 i. Response to alarms;
- 456
- 457 ii. Asphyxiation;
- 458
- 459 iii. Frostbite;
- 460
- 461 iv. Ice plug;

- 462 v. Tipped container;
- 463
- 464 vi. Damaged container;
- 465
- 466 vii. Spill;
- 467
- 468 viii. Over-pressurization and/or explosion;
- 469
- 470 ix. Implosion; and
- 471
- 472 x. Embrittlement of materials.
- 473

474 d. Recordkeeping

475

476 (1) Training shall be provided, documented, and recorded in accordance with the

477 requirements of the NIST S 7101.23: *Safety Education and Training*.

478

479 (2) Oxygen monitor calibration and maintenance records shall be kept:

480

481 (a) For a minimum of two years; and

482

483 (b) In accordance with OU/Division policies and procedures.

484

485

486 **7. DEFINITIONS**

487 a. Bulk Cryogen Storage Tank (BCST) – A liquid cryogen container, normally with a capacity

488 greater than 300 gallons (1,136 L) designed primarily for stationary installations not intended

489 for loading, unloading, or attachment to a transport vehicle as part of its normal operation in

490 the process of use.

491

492 b. Cryogen – A liquid with a normal boiling point below -150 degrees C; applies to either the

493 cryogenic liquid or its gas at or near its boiling point.

494

495 c. Cryostat – A cryogenic vessel configured for low-temperature experiments (as opposed to a

496 dewar which is for storing cryogens).

497

498 d. Dewar – Vacuum-jacketed vessel designed to store cryogens. May be of two types:

499

500 (1) Non-pressurized Storage Dewar – Non-pressurized, vacuum-jacketed vessel with a loose-

501 fitting dust cap over the outlet of the neck tubes, which reduces the chance of

502 atmospheric moisture plugging the neck and allows gas produced from the vaporizing
503 liquid to escape. Depending on the size, liquid is removed by pouring or using a transfer
504 tube. Tubing must be vented to maintain atmospheric pressure and prevent pressurization.

505

506 (2) Pressurized Storage Dewar – Double-walled vacuum vessel with multilayer insulation in
507 the annular space and equipped with safety-relief valves and rupture discs to protect the
508 vessels from pressure build-up. These containers are categorized as either low-pressure
509 (which can operate at pressures up to about 25 psig) or high-pressure (which can operate
510 at pressures up to 350 psig) liquid containers, with varying capacities. Product may be
511 withdrawn as a gas by passing liquid through the internal vaporizer or as a liquid under
512 its own vapor pressure or an external pressure source.

513

514 e. Emergency – A highly dangerous condition that needs to be addressed immediately, which
515 may be caused by an unplanned or unanticipated occurrence such as equipment failure, a
516 container rupture, or an uncontrolled release of a hazardous chemical into the workplace.

517

518 f. Engineering Controls – Include designing or modifying laboratories, equipment, ventilation
519 systems, and processes to reduce or eliminate the exposure to hazardous sources or
520 conditions. Engineering controls are used to remove a hazard or place a barrier between the
521 worker and the hazard.

522

523 g. OU Responsible – The OU with the primary user(s) of the bulk cryogen storage tank.

524

525 h. Oxygen Deficiency – <19.5% oxygen in air, as defined by OSHA.

526

527 i. Oxygen Enrichment – >23.0% oxygen in air, as defined by OSHA.

528

529 j. Signal Word – A word that designates a degree or level of hazard seriousness.

530

531 (1) “Danger” – Indicates an imminently hazardous situation that, if not avoided, **will** result in
532 death or serious injury.

533

534 (2) “Warning” – Indicates a hazardous situation that, if not avoided, **could** result in death or
535 serious injury.

536

537 (3) “Caution” – Indicates a potentially hazardous situation that, if not avoided, **may** result in
538 minor or moderate injury.

539

540 (4) “Notice” – The preferred word to address situations not related to personal injury.

541

542 **8. ACRONYMS**

- 543 a. ACGIH – American Conference of Governmental Industrial Hygienists
544
545 b. ANSI – American National Standards Institute
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547 c. ASME – American Society of Mechanical Engineers
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549 d. ASTM – American Society of Testing and Materials
550
551 e. CGA – Compressed Gas Association
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553 f. COR – Contracting Officer Representative
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555 g. IDLH – Immediately Dangerous to Life and Health
556
557 h. NFPA – National Fire Protection Association
558
559 i. NIST – National Institute of Standards and Technology
560
561 j. ODH – Oxygen Deficiency Hazard
562
563 k. OSHA – Occupational Safety and Health Administration at the U.S. Department of Labor or
564 state level
565
566 l. PPE – Personal Protective Equipment
567
568 m. SOP – Standard Operating Procedure
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571 **9. RESPONSIBILITIES**

- 572 The OUs are responsible for ensuring that the requirements in Section 6 are met.
573
574 a. CORs shall be responsible for including the appropriate language in contracts regarding
575 contractor-provided services.
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578 **10. AUTHORITIES**

- 579 There are no authorities specific to this suborder alone.
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582 **11. DIRECTIVE OWNER**

583 Chief Safety Officer

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585

586 **12. APPENDICES**

587 a. Appendix A. Revision History

588

589 b. Appendix B. Cryogen Properties

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591 c. Appendix C. Hazard Signage

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593 d. Appendic D. Example of BCST Monthly Visual Inspection Form

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Appendix A. Revision History

Version No.	Approval Date	Effective Date	Brief Description of Change; Rationale
1	04/30/13	04/01/14	None – Initial document
2	06/06/19	06/30/23	<ul style="list-style-type: none"> • Requirement added for cryogenic systems that are designed, fabricated, or modified in-house to be designed to withstand pressures of at least 150% of maximum pressure relief on system • Requirement added to include calculations of the proper relief valve size and pressure drop in the hazard review for any cryogen system that is to be designed, fabricated, or modified in-house • Requirement added to include plan as part of hazard review for testing pressure relief devices on cryogenic systems, in accordance with the manufacturer’s or installer’s recommendations • Requirement added related to chemical inventorying of cryogenes. • Added appendix for revision history • Minor edits updating the document • NOTE: Effective date was originally TBD due to COVID-19 pandemic. Updated on 4/17/23.
3	6/22/23		<ul style="list-style-type: none"> • Added Section 3.b to address addition of BCST requirements. • Modification to Section 6.b(2) to clearly indicate requirements for oxygen-deficiency/oxygen-enrichment hazard assessments • Modification to Section 6.b(4)(c) to clearly indicate requirements for tying an O2 monitor into the NIST central fire alarm system. • Added Section 6.b(7) to clearly indicate requirements for BCSTs. • Added definitions for “BCST” and “OU Responsible” in Section 7. • Added COR responsibility in Section 9. • Added two signs to Appendix C. • Added Appendix D.

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Appendix B. Cryogen Properties

Table 1 reflects a partial list of properties for the cryogens included in this suborder, namely, helium, nitrogen, neon, and argon. In addition, since oxygen has the potential to condense on surfaces cooled by cryogens with normal boiling points lower than that of oxygen, thereby posing a risk of explosion or fire, its properties are included here for reference.

Table 1: Properties of common cryogens

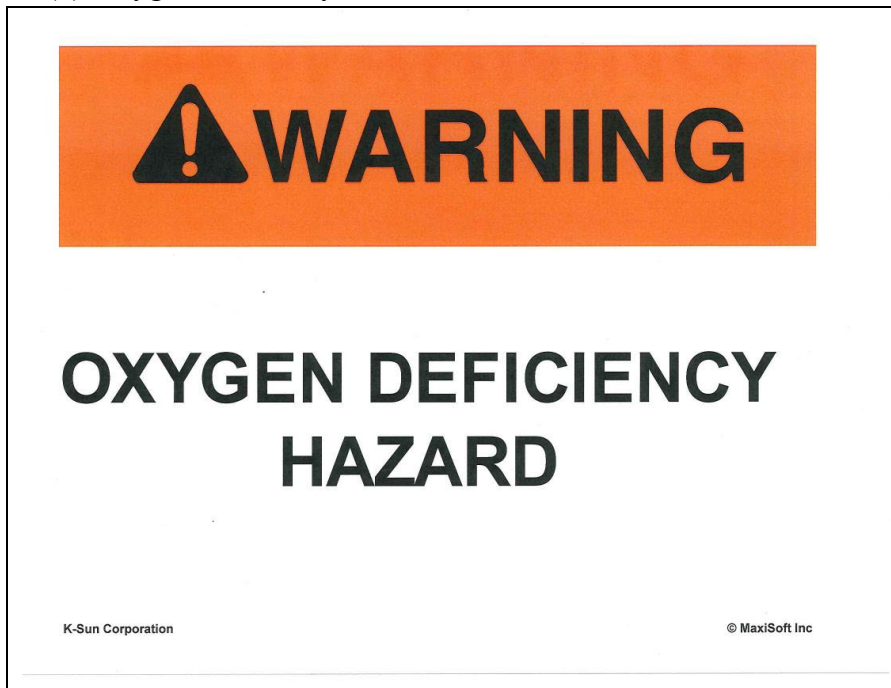
		Helium		Neon		Nitrogen		Argon		Oxygen	
Boiling Point (K)	@Sea level, 101.325 kPa (1atm)	4.2		27.1		77.3		87.3		90.2	
Liquid Density (g/L)	@Sea level, 101.325 kPa (1atm)	125		1207		806		1395		1141	
	Location	273K	293K	273K	293K	273K	293K	273K	293K	273K	293K
Gas Density (g/L)	Boulder	0.15	0.14	0.77	0.72	1.07	1.00	1.53	1.43	1.23	1.14
	Gaithersburg	0.18	0.17	0.90	0.84	1.25	1.17	1.78	1.66	1.43	1.33
Gas/liquid Expansion Ratio (from liquid to gas, local atm)	Boulder	813	873	1561	1676	751	806	911	978	930	998
	Gaithersburg	698	750	1341	1439	644	692	782	839	798	857

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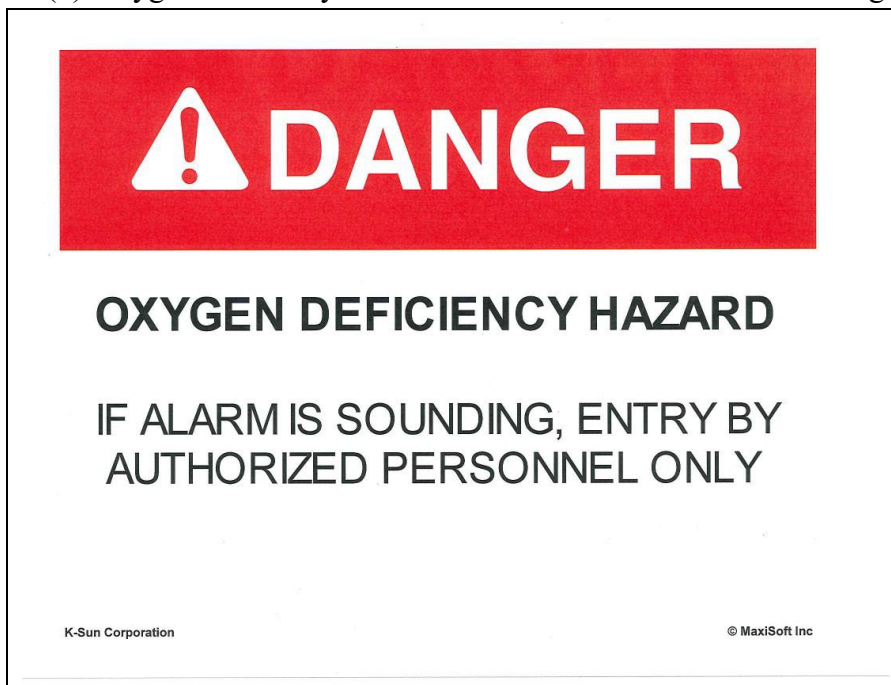
Appendix C. Hazard Signage

(1) Oxygen deficiency hazard



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(2) Oxygen deficiency hazard – Do not enter if alarm is sounding



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618 (3) Do Not Enter Elevator



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(4) Suffocation (Asphyxiation) Warning Symbol






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625 (5) Cold Warning Symbol



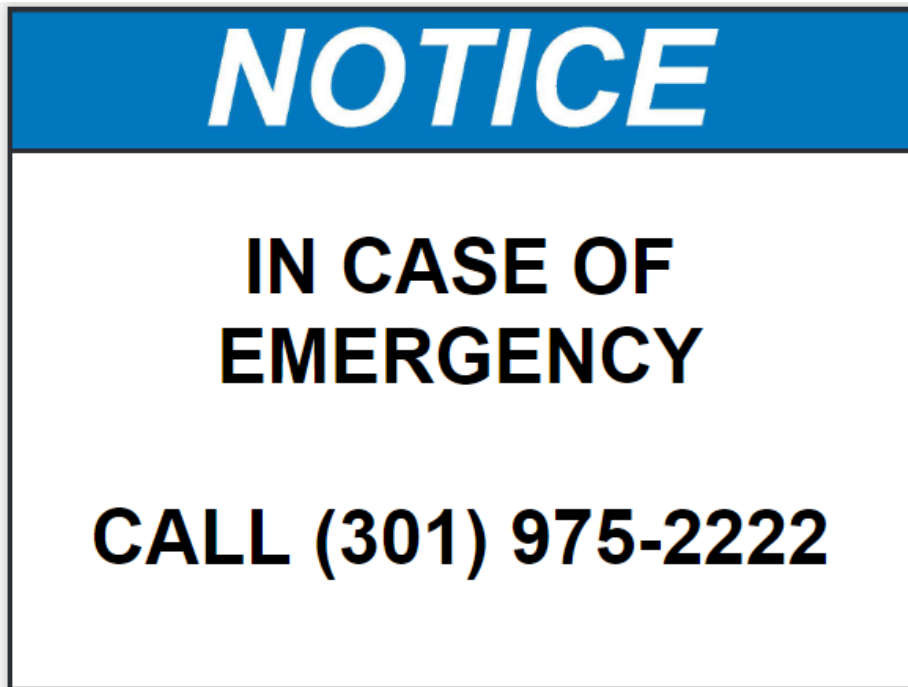
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(6) Warning for liquified nitrogen gas

 WARNING	
<p>NITROGEN (REFRIGERATED LIQUEFIED GAS)</p> <p>Hazards: Contains refrigerated gas; may cause cryogenic burns or injury. May displace oxygen and cause rapid suffocation.</p> <p>Precautions: Wear cold insulating gloves, face shield, and eye protection. Use and store in a well-ventilated place.</p> <p>Response: Remove person to fresh air and keep comfortable for breathing. Thaw frosted parts with lukewarm water. Do not rub affected area. Get immediate medical attention.</p>	 

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635 (7) Notice signs for BCSTs on the NIST-Gaithersburg campus
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Appendix D: Example of BCST Monthly Visual Inspection Form



**BULK CRYOGEN STORAGE TANK (BCST)
MONTHLY VISUAL INSPECTION FORM**
Routine in-service visual inspection of tank exterior and surroundings

Tank Location: _____ Contents: _____

Inspector: _____ Date: _____

Signage present:	Observations:	Corrective actions required:
Occupant sign	Yes / No	
Hazard sign	Yes / No	
NFPA diamond	Yes / No	
Gaithersburg phone #	Yes / No	
Excessive ice buildup	Yes / No	
Trash accumulation, etc.	Yes / No	
Unusual visible/audible release	Yes / No	
Tank pressure		
Evidence of:		
Leaks	Yes / No	
Shell distortion	Yes / No	
Signs of settlement	Yes / No	
Corrosion	Yes / No	
Condition of:		
Foundation	Good / Poor / Changed	
Paint coating	Good / Poor / Changed	
Insulation systems	Good / Poor / Changed	
Appurtenances	Good / Poor / Changed	
Physical Security	Good / Poor / Changed	
Date(s) required corrective action(s) reported to Supervisor/OU/Contractor:		
Date/Comments: _____		

The OU must retain this inspection record for at least five years.

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