Engine Nacelle, Halon Replacement

Reconsidering Carbon Dioxide as a Fire Extinguishant ~ Status

Presented to:

FAA International Aircraft Systems Fire Protection Working Group,
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By:

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Brief Project Overview

A. Why revisit carbon dioxide (CO_2) ?

1. An existing fire extinguishing agent with history
2. Past and current use in ground-based systems, and aviation
3. Currently recognized as acceptable by the FAA
   a. Advisory Circular 20-100/1977 (1)
   b. Must satisfy 37%v/v CO_2 for ½ sec in the powerplant fire zone
4. Thinking existing concentration requirement can be reduced…
   a. Will put CO_2 through testing similar to MPSHRe rev04 (2)
   b. Will report outcomes when finished, regardless of outcome

Project Goals/Status

A. Goals

1. Assess CO_2 via MPSHRe rev04
2. Present results

B. Aspect(s) in progress…

1. Establishing CO_2 storage & usage techniques
   a. Investigating/refining the cyclical-use process
      1) Pre- & post-test storage vessel handling/transport
      2) CO_2 servicing & thermal-conditioning
      3) CO_2 injection during a test
   b. Addressing a pressure-integrity problem with the storage vessel

C. Aspect(s) not yet started…

1. MPSHRe rev04 testing with CO_2 …

Current Challenges

A. Creating a variable-volume storage vessel (VV02)

1. Needs to be "easily" & "reliably" serviced; i.e. hand-portable
2. Current design has pressure-integrity weakness at its neck seal
   a. VV02 will require repeated handling/transport during testing
   b. An o-ring seal is repeatedly failing after pressurizing 3-4 times
   c. Repair requires full dis- & reassembly after each o-ring failure
   d. Reviewing/reworking design to eliminate this o-ring seal…
3. Will <u>not</u> N_2-pressurize CO_2 in VV02 during MPSHRe testing

B. Learning about thermally-conditioning CO_2 in VV02

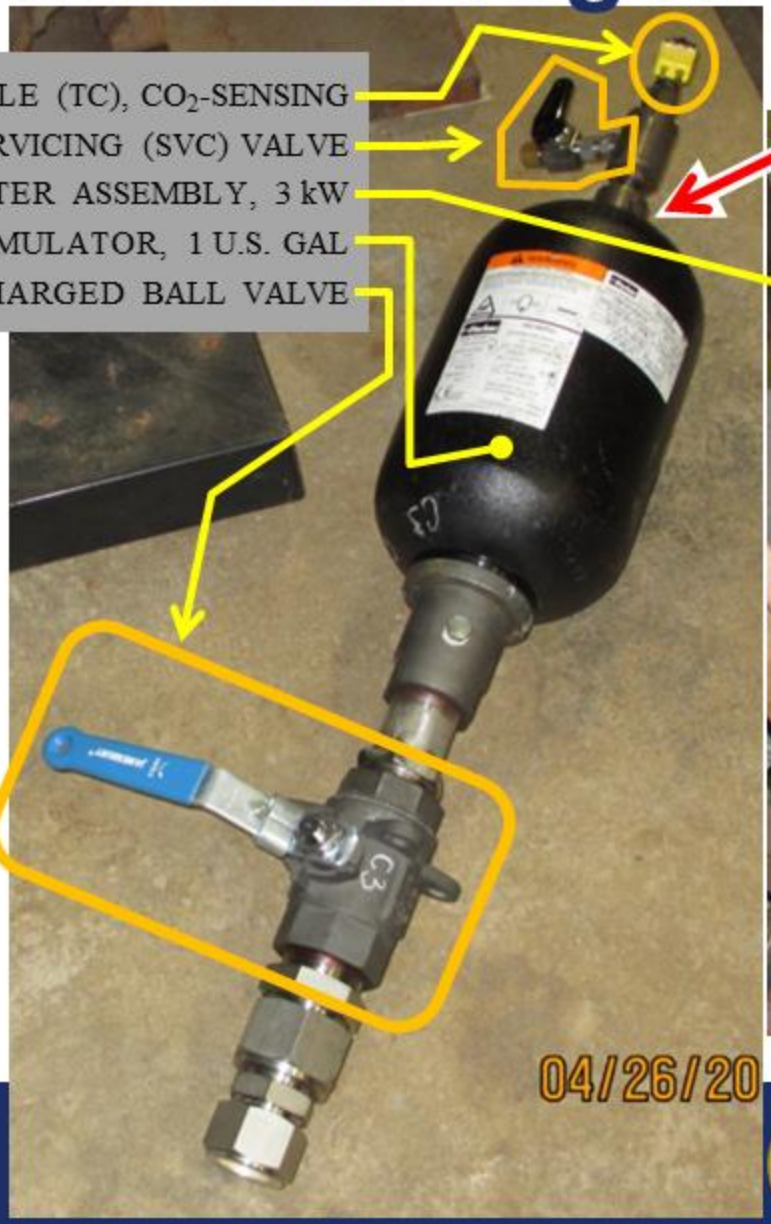
1. Modified & using an existing electrical heating system
2. Have 3 recent trials to characterize heating VV02 & CO_2

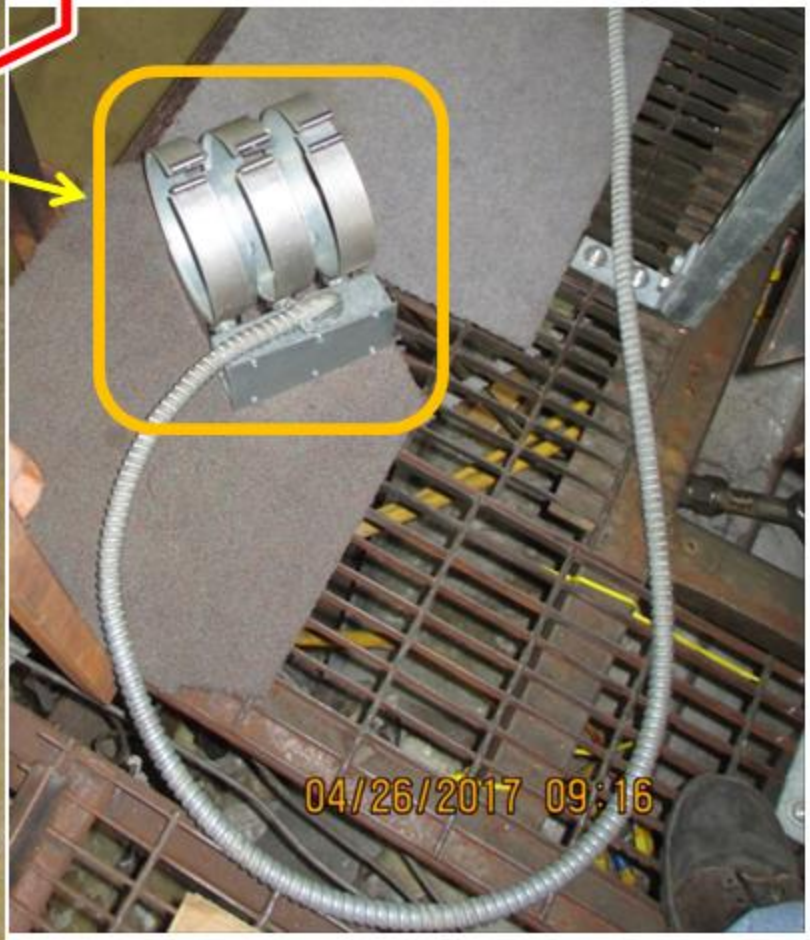
Current Challenges

REPEATEDLY-FAILING O-RING LOCATED HERE (at the neck seal)

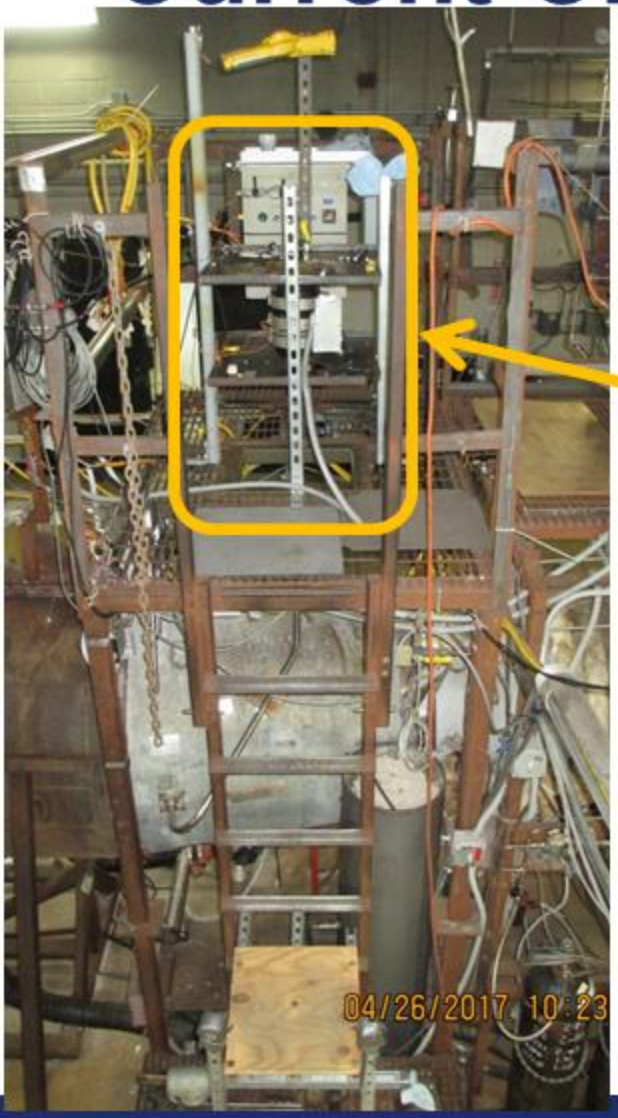
VV02…

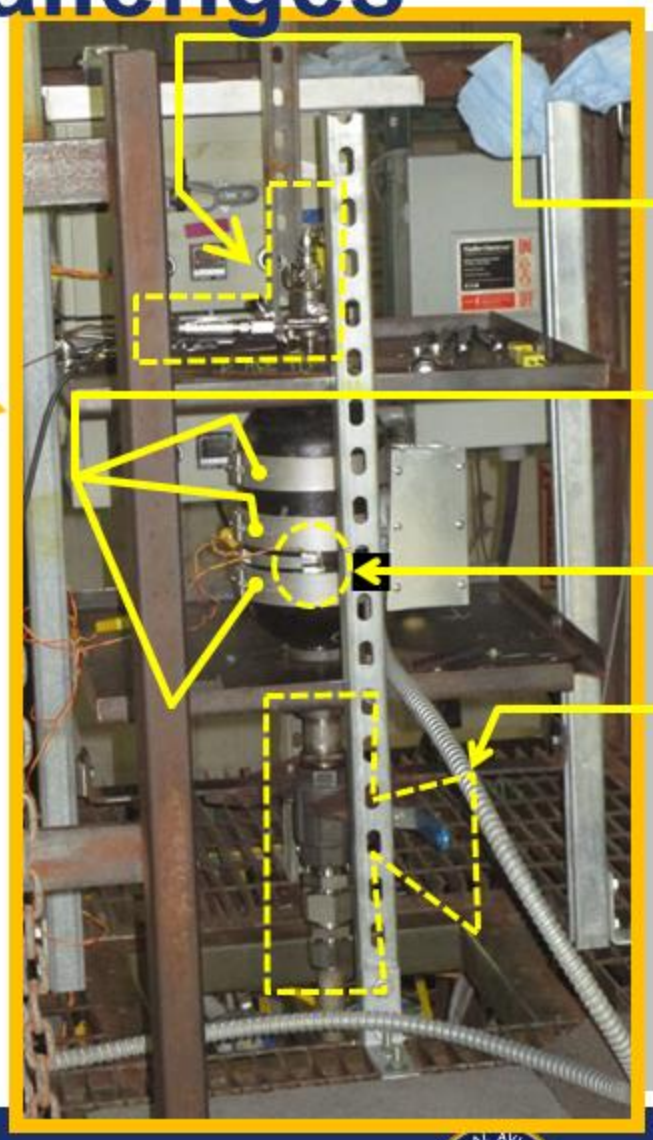
THERMOCOUPLE (TC), CO_2-SENSING
SERVICING (SVC) VALVE
VV02 BAND-HEATER ASSEMBLY, 3 kW
HYDRAULIC ACCUMULATOR, 1 U.S. GAL
MANUALLY-DISCHARGED BALL VALVE





Current Challenges





VV02 installed…

(NOT EASILY VISIBLE)

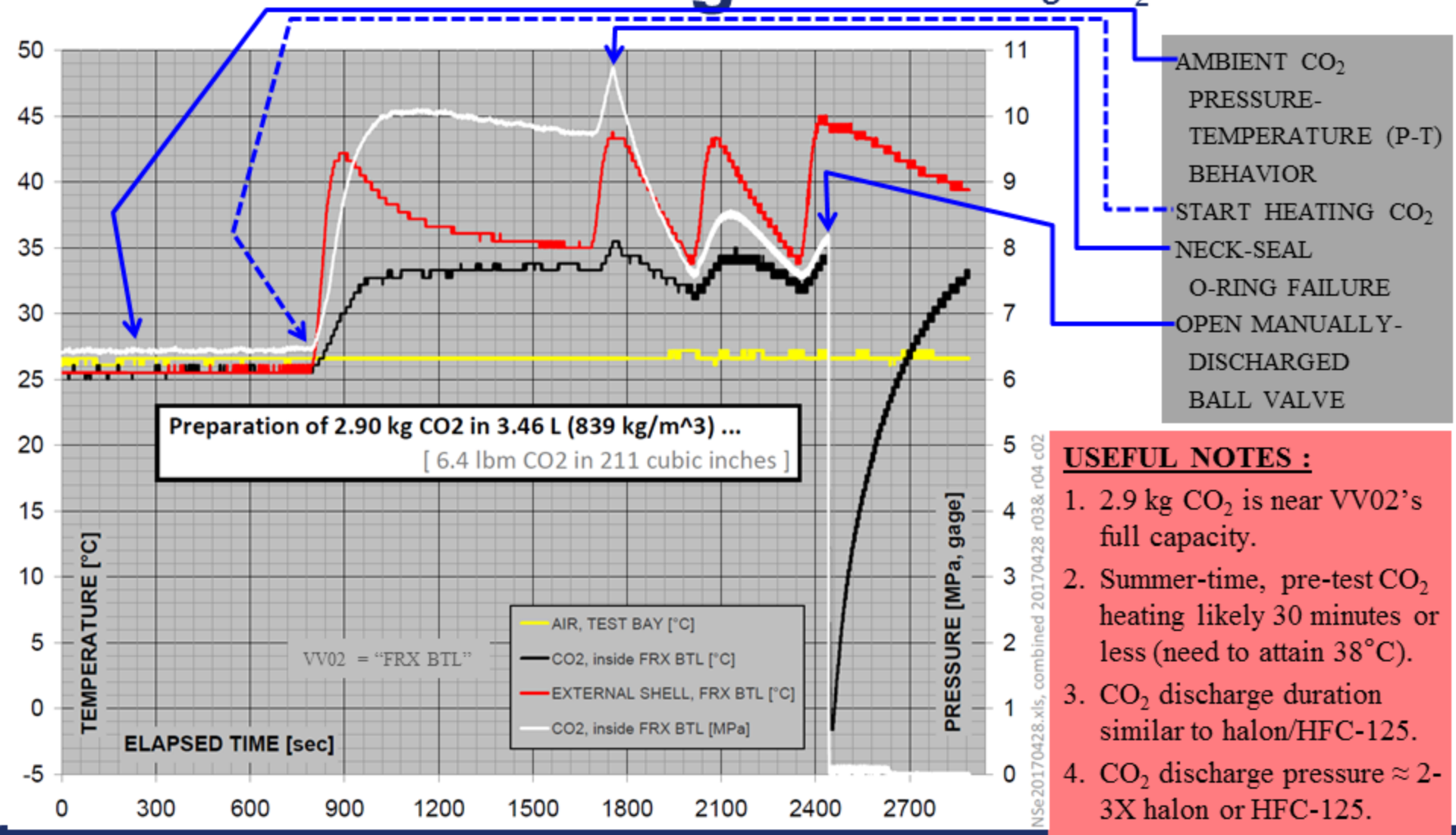
- TC, CO_2-SENSING
- SVC VALVE
- PRESSURE TRANSDUCER, CO_2-SENSING

- VV02 BAND HEATERS
- TC, VV02 SHELL

- MANUALLY-DISCHARGED BALL VALVE

Current Challenges

Heating CO_2 in VV02/C …



USEFUL NOTES :

1. 2.9 kg CO_2 is near VV02's full capacity.
2. Summer-time, pre-test CO_2 heating likely 30 minutes or less (need to attain 38°C).
3. CO_2 discharge duration similar to halon/HFC-125.
4. CO_2 discharge pressure ≈ 2-3X halon or HFC-125.

Summary

A. In the near-term, will :

1. Prevent occasional VV02 faulty pressure integrity
2. Further refine CO_2 heating in VV02
3. Commence testing with CO_2 per MPSHRe rev04

Thank you.

Appendix

References

1) Advisory Circular 20-100, 1977, "General Guidelines for Measuring Fire-Extinguishing Agent Concentrations in Powerplant Compartments," United States Department of Transportation, Federal Aviation Administration, Washington, D.C. http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC20-100.pdf

2) Ingerson, D., 2010, "Minimum Performance Standards for Halon 1301 Replacement in the Fire Extinguishing Agents/Systems of Civil Aircraft Engine and Auxiliary Power Unit Compartments, revision 04", draft/working document, United States Department of Transportation, Federal Aviation Administration, W.J. Hughes, Technical Center, Atlantic City, NJ. http://www.fire.tc.faa.gov/pdf/systems/MPSErev04_MPSeRev04doc-02submtd.pdf

3) Yang, J.C., Cleary, T.G., Vázquez, I., Boyer, C.I., King, M.D., Breuel, B.D., Womeldorf, C.A., Grosshandler, W.L., Huber, M.L., Weber, L., and Gmurczyk, G., "Optimization of system discharge," in Gann, R.G., ed., Fire Suppression System Performance of Alternative Agents in Aircraft Engine and Dry Bay Laboratory Simulations, NIST SP 890: vol. I, U.S. Department of Commerce, Washington, DC, November 1995. http://www.nist.gov/customcf/get_pdf.cfm?pub_id=911554

Appendix

Explain the Change in Testing from CO_2 & N_2 to CO_2 alone

A. VV02 experiencing pressure integrity issues

1. Want to reduce its internal storage pressure
2. Doing so to reduce impact on VV02 seals

B. Check if CO_2 P-υ-T behavior at 38°C/100°F presents a disconnect with prior MPSHRe-test experience

1. For halon 1301 & HFC-125, "benchmark" configurations required storage pressures ≈ 4.96 MPa/720 psig[(a)]

Bottle Fill	Density	Pressure @ 38°C/100°F
CO_2 & N_2 [(b)]	786.5 kg/m^3 (49.1 lb/ft^3)	20.5 MPa (≈ 2970 psig)
CO_2		14.3 MPa (≈ 2080 psig)

2. Pressure-insult from injecting pure CO_2 still exceeds experience, so CO_2 alone it is…

(a) BASED ON A SERVICE POINT OF 600 psig/4.14 MPa @ 70°F/21°F (which for this closed system includes a P-T point of 292 psig @ -65°F)
(b) BASED ON A P-T POINT OF 292 psig/2.01 MPa @ -65°F/-54°C

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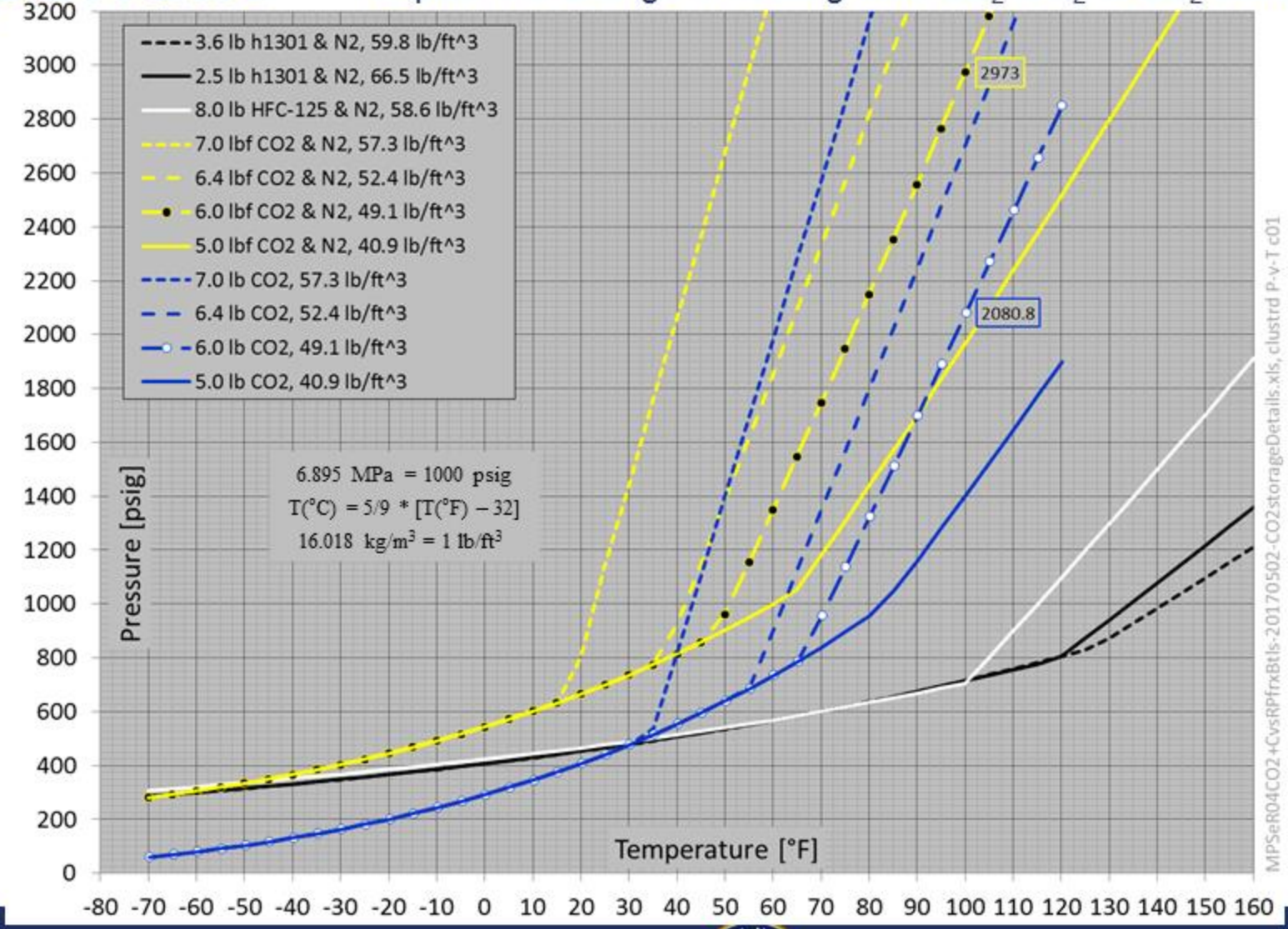

Appendix

Detailed VV02/C Installation Imagery