The History of Venting (Part I)

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(Improved) Abstract

Venting techniques and design are an important implementation strategy for observatory and payload contamination control, and yet venting analysis has seen a topsey turvey history, at lease from the perspective of the simple Layman trying to design a black box.

Additionally, designing the vent has competing controls from Safety and EMI/EMC. In the days of Shuttle, Safety placed liens against the vents of blankets, boxes, and large structural items principally to protect cargo bay vents but also from a flammability perspective.

What continues to elude the Designer Community is a stable, simple way of designing vents for black boxes that satisfies everybody. But we continue to try.

Overview of Year-Events

- 1983 – TM-85016 published (CC for telescopes in cargo bay)
- 1983 – Venting of Space Shuttle Payloads TP
- 1986 – GEVS-SE Revision Dash published
- 1991 – Hubble SIC&DH (etc.) box-level Venting Specification produced
- 1993 – Safety (ISRP) gets tagged with Venting Duty
- 1996 – Spacecraft Compartment Venting TP
- 1997 – Hubble Servicing Mission -2 is flown
- 2011 – JSC ISRP inserts MEVR requirements in standard hazard reports
- 2015 – Bail-out tactics when you forgot to put vent holes
- 2017 – ISRP retracts from MEVR & replaces with no-vent FSu

1983

- **1983 – TM-85016 published (CC for telescopes in cargo bay)**
  - **"Abatement of Gaseous and Particulate Contamination in a Space Instrument Application to a Solar Telescope" by John J. Scialdone April 1983**
    - **Highly detailed paper (9 pages) with Keywords: gaseous purging, internal gas dynamics, gas diffusion, Shuttle environment, rarefied gas dynamics**
    - **I infer that OSL (Orbiting Solar Laboratory) was the primary sponsor for this paper. OSL became a Delta Launch (not a Shuttle launch) at the finished-proposal level, many years later**
    - **Paper quanitatively shows the benefits of having K-bottle purge plumbed into a telescope wherein the k-bottle is "Airborne Support Equipment"**
    - **Paper might have also had sponsorship from Starlab and/or the ASTRO mission (BBXRT, IUT, HUT) on a Spacelab Pallet via IPS (Instrument Pointing Subsystem)**
    - **BBXRT had a dewar and a dewar pumping system plumbed onto it's side (flew)**
- **1983 – Venting of Space Shuttle Payloads Technical Paper**
  - **Very practical and useful 2 pages description of test-venting an enclosure as the external pressure is dropping off to mimic Shuttle bay venting (AIAA paper 83-2600 and A84-10936)**

1986 - 1991

- **1986 – GEVS-SE Revision 'Dash' published**
  - GEVS-SE is General Envi. Verification Specification – Shuttle and ELV
  - Does anybody have a copy of revision dash from about 1986 ?
  - Clearly it published that 0.25 square-inch vent per cubic foot of otherwise sealed volume will be deemed No-Test
  - The requirement seems to have made good use of the "Venting of Space Shuttle Payloads" Technical Paper and deemed that a few seconds of 0.5 psi differential pressure was close enough to nothing as to qualify for no-test
  - This satisfactory situation disappeared upon revision A (forever)
- **1991 – Hubble SIC&DH box-level Venting Spec produced**
  - The Science Instrument Command & Data Handling is an expensive ORU (orbital replacement unit) consisting of several metal boxes with EMI containment requirements. Demanded a A/V versus residual-pressure curve for boxes inside the telescope
  - The Design community settled on 0.10 inch^{-1} and 0.11 psi for box use

1993 - 1996

- **1993 – Safety (ISRP) gets tagged with Venting Duty**
  - **ISRP is ISS Safety Review Panel (was) PSRP**
  - **ELV Payloads never had an external panel like manned space flight**
  - **For the Hubble servicing missions and other Shuttle-based missions, Safety incurred many sets of requirements for Multi-Layered Insulation construction and Box venting, including:**
    - **Flammability – crew sits on top of payload in air during Interface Verification Test**
    - **Grounding of each layer of MLI – A single failure in an Orbiter APU can infuse cargo bay with hydrazine vapors**
    - **Do Not Clog – the cargo bay vents with MLI debris either from:**
      - **a loose piece of MLI coming off the payload**
      - **or a puffed-up and split MLI assembly not adequately vented within itself**
- **1996 – Spacecraft Compartment Venting Technical Paper**
  - **GSFC has thermal-vacuum chambers with rapid-enough pump-down capability to serve as an ascent simulator**
  - **Tried for “A simple rule for the evaluation of the compartment response………”**

1997 - 2011

- **1997 – Hubble Servicing Mission -2 is flown**
  - Because boxes and flat ends of cylinders make poor pressure vessels (due to corner bending loads) we had three safety rules of thumb:
    - For effective vent ratio of 0.25 square-inch per cubic foot (or better), no further analysis is necessary for "adequate venting"
      - Note that almost all of our avionic and ORU boxes were legacy-built prior to the loss of GEVS-SE revision dash
    - For effective vent ratio of 0.10 square-inch per cubic foot (or better), a distributed pressure analysis for 0.11 psi is necessary for "adequate venting"
      - Note that this was applied to macro-level avionic boxes, not the small Interpoint power converter lids
    - Mesh-covered vents need to account for the effective loss of vent area versus that which would exist if this was a clear through-hole
      - For example, we used 500 strands per inch 0.oo1" diameter strands loomed into a mesh material. The effective vent area is only 26% of the total area of the mesh
- **2011 – JSC ISRP inserts MEVR requirements as 'Standard'**
  - Maximum Effective Vent Ratio (cubic inches enclosed/square inches vent) to be < 2000 inches.
  - In GEVS-speak this would be 0.864 square-inch vents per cubic foot
  - Resulting in 0.01 psi residual pressure (modules >> avionic boxes)

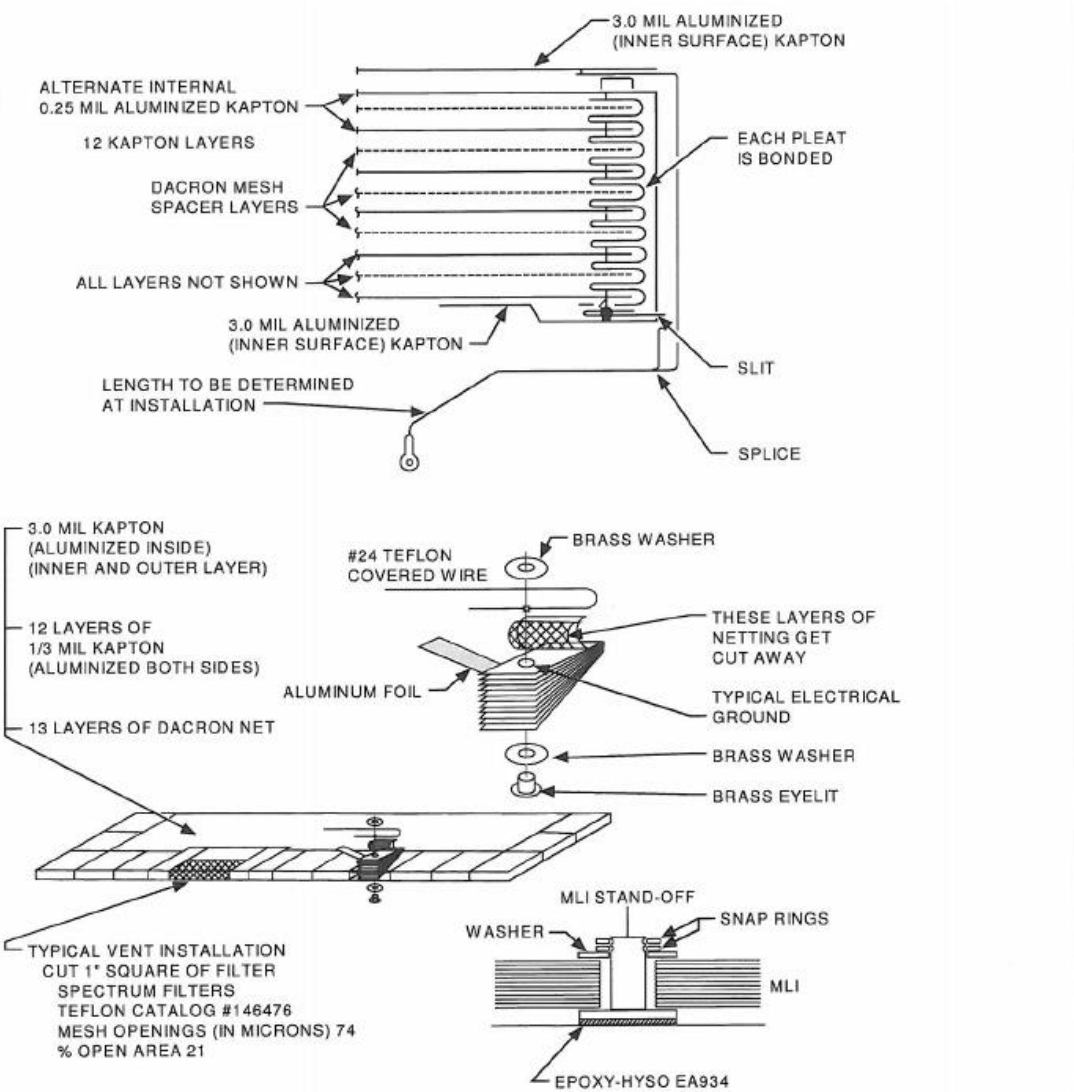
2015 - 2017

- **2015 – Leiter develops Bail-out tactics when designer people forget to put vent holes into the box:**
  - **It is a project policy whether to fill unused pin-sockets on D-sub connectors or not**
  - **There is the opportunity to recover vent holes by leaving unused sockets as Open**
- **2017 – In at least one case, ISRP retreats from MEVR requirements and replaces with no-vent FSu**
  - **The same complexities exist for the Trunk environment as before (choked-flow, transonic, max-Q, the system effect of a few seconds of choked flow) but with less data**
  - **ISRP seems to have reassessed their original charter for requirements. Safety is basically strength requirements**
  - **Most cargo is OFF for two days cruising to the ISS dock (i.e. no Corona by the time the ISS is proximate to a powered payload)**
  - **What to do? Follow the HST SM-2 example**

Honeycomb Panels

- Strength is not the issue for intra-cellular burst
- However, Virtual Leaks would be a major concern for I&T
- Residual pressure can add-up quickly for a large enclosure. For example a 4x8 plywood panel with 0.5 psi has 2,304 pounds on it, so vent the Observatory carefully in a way that carries the particulates out
- Vent the panels for intra-cellular air by specifying vented core and then venting the Outside skins at 1" centers
- This will carry the manufacturing debris away from the interior of the instrument
- Also the inside might need flat black paint and this would clog the small vent holes in the skins

Multi-Layered Insulation (MLI)



Typical Black Box

- **EMI/EMC controls are typically unappreciative of through-holes. Solutions are to use mesh or labyrinth seals that approximate a light-tight box**
- **Flammability "Chimney Effect" requires a metal box to not-vent more than 1% of the total box surface area (six sides)**
- **Bake-out Circuit Card Assemblies prior to installation into an avionics box**
- **Bake-out box intra-harnesses prior to installation**