

## SPECIFICATION FOR A RF SHIELDED ENCLOSURE

1. Scope - This specification covers the general requirements for the design, construction, erection, and testing of a RF shielded enclosure. It includes associated and auxiliary components furnished as part of a complete installation that shall provide the following:
  - a. Architecturally styled RF doors and windows.
  - b. RF attenuating filters for power, telephone, and signal lines.
  - c. High frequency waveguide “pipes” for fiber optic feedthrus.
  - d. Electrical wiring, lighting, and heating /cooling of the enclosure.
  - e. Proper penetration of the shield, as required.
  - f. Honeycomb grills for HVAC vents and floor drains.
  - g. Conductive metallized fabric or copper foil on walls, ceilings and floors.

It is important to note that most of the requirements herein are applicable to any high quality shielded enclosure, but the requirements for frequency range, shielding effectiveness, and filter insertion loss should be tailored to meet the actual needs of the owner. Furthermore, if the enclosure is to reside in a salt air or other harsh environment, material selection and the management of dissimilar metals will require additional scrutiny to assure long term reliability.

2. Applicable Documents - The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

|               |   |
|---------------|---|
| IEEE-Std-299  | IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures                          |
| MIL-STD-220   | Method of Insertion Loss Measurement for Radio Frequency Filters  |
| QQ-S-571F     | Federal Specification Solder, Electronic (96 to 485 °C)   |
| ASTM E-84-91a | Test for Surface Burning Characteristics of Building Materials  |
| ASTM D4496    | Test Method of DC Resistance or Conductance of Moderately Conductive Materials  |
| MIL-HDBK-1250 | Department of Defense Handbook Corrosion Prevention and Deterioration Control in Electronic Components and Assemblies |

### 3. Ground Rules

- a. *Discrepancies* - Discrepancies shall be resolved to the owner's satisfaction prior to proceeding otherwise. This applies to discrepancies within this document and between this document and the applicable documents listed herein, and any other relevant documentation. In most cases, the requirements of this document will take precedence over all other documents, but discrepancies noted by the contractor shall be promptly reported to the owner, who will make the final determination.
- b. *Coordination* - When multiple subcontractors are involved, particular care shall be taken in coordinating the activities of the various trades to insure that the shielding integrity and reliability is maintained. Perpetuating the awareness of such concerns is an integral part of the shielding contractor's responsibility.
- c. *Reliability* - The construction and installation shall include those features that will result in reliable and stable characteristics with a minimum requirement for maintenance work. The contractor shall demonstrate that the material selected will continue to meet the performance requirements herein for well beyond the warranty period.
- d. *Corrosion Prevention* - To promote long-term reliability, the corrosion prevention practices of MIL-HDBK-1250 shall be employed. In no case shall dissimilar metals with an anodic index difference greater than 0.5 V be used in close proximity to each other. Zinc plated materials shall not be used. Copper metallized fabric shall not be used.
- e. *Definition of Shielding Effectiveness* - For the purposes of this specification, an enclosure will be considered to have a shielding effectiveness of x dB, if and only if no single point on it has a shielding effectiveness of less than x dB per the procedures of IEEE-Std-299. The required shielding effectiveness shall apply to any point, at any frequency in the specified range for both vertical and horizontal polarities. This includes but is by no means limited to the frequencies and points selected for the purposes of acceptance testing.
- f. *Commercial-off-the-shelf (COTS) material* - COTS material shall be used to the maximum extent possible.
- g. *Equivalency* - Equivalency of materials shall be confirmed with the owner.
- h. All requirements, including test requirements, apply to walls, floors and ceilings.

4. Preproduction and Preinstallation Approval - Prior to starting work or procuring material, the contractor shall submit to the owner, documentation of sufficient detail to show that the contractor has a plan from start to finish that will lead to the completion of a finished product that will meet the intent of this specification, while minimizing risk to the owner. The documentation shall include but may not be limited to, manufacturers' data sheets, material safety data sheets, photographs of previous usage, mechanical drawings, wiring diagrams and parts list. The contractor shall provide such information well in advance of work commencement. The exact timing should be agreed to at contract award or shortly thereafter. Unless otherwise specified by the owner, such information shall be provided not less than 30 days prior to the desired approval date.
  
5. Material Selection - All materials and labor necessary to complete the project, even though they may not be specifically identified, shall be provided by the contractor. All materials shall be in accordance with applicable referenced documents, new and undamaged, and of quality and design consistent with the proposed use. All metal materials shall be, or made to be (with proper treatment), galvanically compatible with other metal materials they will be in contact with. Where applicable, ageing, seaming and other factors that may degrade performance, shall be considered. When a definite material is not specified, a material shall be used which will meet the requirements of this specification. When there is doubt, the contractor shall be diligent in consulting the owner. The following are some specific material considerations:
  - a. *Conductive Fabric* - Conductive fabric shall be equal to Laird Technologies, formerly Advanced Performance Materials (APM), Flectron 3027-217 metallized material, nickel/copper nonwoven fabric, 54" wide. Since using a narrower material would result in more seams, a narrower material shall not be used.
  - b. *Copper Sheets* - Copper sheets shall be a 3-oz solid copper or better.
  - c. *Copper tape* - Copper tape shall be Bron Tapes BT-726 or equivalent and shall have conductive adhesive.
  - d. *Solder and Flux* - Solder and flux shall be in accordance with the applicable requirements of Federal Specification QQ-S-571-F. Flux shall be type RMA. Low melting temperature solder such as type Sn63Pb37 or Sn60Pb40 solder shall be used to seam copper foil. (Could use some more work.)
  - e. *Shielded Doors* - Unless otherwise specified or agreed to, shielded doors shall be COTS models purchased from an established and reputable vendor. The advertised shielding effectiveness of the doors shall be at least 10 dB greater than the shielding effectiveness required for the enclosure. The mechanical design of the doors shall be demonstrated to be in line with the intended level of usage.

- f. *Honeycomb Filters* - COTS hex cell honeycomb filters, with attenuation characteristics consistent with this specification, shall be used as required.
  - g. *Adhesives* - Roman Pro 880 adhesive or other water-based adhesives shall not be used. The contractor shall be diligent in researching the compatibility of all adhesives to be used in this project. The contractor shall demonstrate to the owner that this has been done prior to procuring or using any adhesive. Simply saying “we have been using it for years” or “we have installed hundreds of these in this fashion” does not constitute proof of successful use unless data that confirms continued acceptable shielding and structural performance is provided.
  - h. *Fasteners* - Fasteners shall be galvanically compatible with materials they touch and shall be corrosion resistant. They shall be of appropriate grade.
  - i. *Nonconductive Paints and Sealers* - Unless otherwise directed or specified, the stipulations of 5 g. apply.
  - j. *Conductive Paint* - This specification does not address the use of conductive paint, but the owner acknowledges that conductive paint may be useful and appropriate for this project. If the contractor can demonstrate compliance with the requirements herein, and the ability to apply it to the manufacturers specified consistency and thickness, conductive paint may be used.
6. **Workmanship** - The enclosure, including all facilities, parts and accessories shall be constructed, finished and installed in a thoroughly workmanlike manner, shall be free from defects which might affect appearance, serviceability or reliability and shall conform to applicable specifications, standards and drawings. Installation shall be so conducted as to avoid damage to other surfaces, and to public and private property in the area; any damage thereto shall be the responsibility of the contractor.
7. **Minimum Attenuation Levels** - Upon completion of the enclosure, the attenuation levels of the enclosure to planewave fields shall not be less than those expressed in Table 1 below. (May need to go higher, should be tailored to owner’s requirements)

| Frequency | 150 MHz | 327 MHz | 600 MHz | 1 GHz | 1.42 GHz | 2.0 GHz |
|-----------|---------|---------|---------|-------|----------|---------|
| SE        | 60 dB   | 60 dB   | 60 dB   | 60 dB | 60 dB    | 60 dB   |

Table 1

For the purposes of testing, discrete test frequencies are identified herein, but SE performance requirements apply to any frequency that falls within the range of 30 MHz to 2 GHz.

## 8. Structure

- a. *Size* - The size and location of the enclosure shall be as specified in the contract.
- b. *Finish* - All structural surfaces shall be clean, smooth and properly painted or sealed before applying conductive lining. Any surface defects that could puncture or otherwise compromise the performance of the conductive lining shall be eliminated prior to its application. Prior to the application of any conductive lining, the owner shall be given an opportunity to inspect structural surfaces.
- c. *Ceilings* - Ceilings shall be composed of gypsum wallboard, or similar material. It shall be installed using standard drywall hanging and finishing practices.
- d. *Walls* - Walls shall be composed of gypsum wallboard, or similar material. It shall be installed using standard drywall hanging and finishing practices.
- e. *Floors* - Concrete floors shall be sealed with a sealant that is compatible with the shielding material and adhesive.
- f. *Entrances* - The number of access waveguide walkways, vestibules and doors and door swing shall be specified in the contract. Doors shall be visually similar to the standard interior doors. The jambs shall be galvanically compatible with the shielding material.

## 9. Installation Details

- a. *Air Conditioning Requirements* - Air conditioning requirements shall be as specified in the contract. Waveguide air vents shall be supplied by the contractor and installed in a manner consistent with paragraph 10a.
- b. *Filter Mounting* - All AC power filters shall be installed per NEC requirements. To insure a good seal against the RF shield, a RF gasket shall be placed between filter panels and boxes and the shield. Care shall be taken when mounting filters that a good electrical bond exists between the filters and the panels or boxes. Proposed filter panel design and location shall be reviewed with the owner.
- c. *Grounding* - Shall be accomplished at a single point via a 1/2" diameter threaded solid copper grounding stud on the RF shielded room.

- d. *A.C. Power and Lighting* - A.C. power and lighting shall be as specified in the contract and shall be supervised or executed by the shielding contractor. A central design goal for the AC power and lighting system shall be to minimize shield penetrations.
  - e. *Floor* - The parent-room floor shall be free of any dirt, dust, debris, or other obstructions. On concrete floors or where there is a substantial risk condensation moisture will form, 3-oz copper sheets shall be used. The 3-oz copper sheets shall be attached to the floor using a thermosetting resin which is compatible and appropriate for use with the copper sheets. Seams shall be properly overlapped and continuously soldered. Where appropriate, metallized fabric may be used on the floors, with the consent of the owner. The floor shielding material shall be installed to a minimum of 4" up on all existing room walls, thus forming a "pan" configuration. The floor shielding shall be protected with stringers and subfloor sheathing.
  - f. *Conductive Fabric* - Conductive fabric shall be applied to the existing room walls, ceiling, and floor (if applicable) as described in the Flectron Installation Manual available on the Laird web site. Golden Harvest GH-50 (or equivalent) vinyl-to-vinyl adhesive shall be used to install conductive fabric. All surfaces shall be free of dirt, dust, grease, and sharp protrusions. Fasteners shall be isolated from the conductive lining, particularly when a corrosion risk exists. The installation procedures identified in the Flectron Installation Manual shall be followed, regardless of the type of metallized fabric used.
10. *Penetrations* - All penetrations shall include a 6"x6" minimum flange as a mechanical means of ensuring a proper RF gasketing surface and structural support. Extreme care to assure galvanic compatibility and mechanical reliability shall be taken. The following are some specific requirements for various penetrations:
- a. *HVAC Vents* - Hex cell honeycomb type grills, matched to the requirements of this specification, shall be provided for all HVAC vents. Grills shall be bonded to the RF shield and properly supported mechanically. Wood collar or other appropriate frames on the outside of the shield shall be used as a dielectric break whenever duct work is to penetrate the shield. HVAC honeycomb vents shall not adversely affect air flow.
  - b. *Pipe Penetrations* - Shall be of the dielectric break type, with a minimum of four diameters of conductive pipe length on the interior of the shield if gas is to be conducted, and eight diameters of conductive pipe length if liquids are to be conducted. The interior connection of the pipe to the copper shield shall be

galvanically correct and shall not leak electromagnetic energy per the levels of this specification

- c. *Waveguide "Pipes"* - To allow passage of non-conductors such as fiber optic cables and plastic pipe, shall be at least seven diameters long for fiber optic cable and eight diameters long for plastic pipe. The connection of the waveguide "pipe" to the RF shield shall be galvanically and mechanically correct.
- d. *Filters* - A filter shall be provided for each incoming power, telephone and signal line penetrating the enclosure. All filters shall provide a minimum of 80 dB of insertion loss from 150 kHz to 2 GHz, measured full load per MIL-STD-220 and shall be designed to carry the primary voltage and current specified in the contract. Filter selection shall be reviewed with the owner. (This should be better tailored to requirements.)
- e. *Floor Drains* - Floor drains shall include a honeycomb type grill arrangement which is mechanically compatible with its intended use. The grill shall be bonded to the shield. For metallic drain pipes, a dielectric break, on the outside of the shield will be required.

11. Responsibility for Testing and Inspection - Unless otherwise agreed to, the contractor shall be responsible for the performance of all testing and inspection requirements. When appropriate, the contractor may use his own or other facilities in pursuit of this. Unless otherwise agreed to, the contractor shall provide the required personnel and test equipment.

12. Testing:

- a. *Test Methodology* - The test methodology of IEEE-Std-299 shall be used. It is understood that the number of test points required by IEEE-Std-299 may not be practical for large enclosures. The number of test points may therefore be tailored accordingly with the concurrence of the owner. The owner reserves the right to specify which points and how many points will be tested. Planewave measurements shall be taken at various points per Table 1 and IEEE-Std-299. Leakage checks must also be made all around exterior doorframes, windows, filters, and other penetrations. The quality of the seams shall be verified in the same manner. All tests shall be run with the receiver inside and the transmitter outside the enclosure. When it is impossible or impractical to maintain the standard reference level separation distance between transmit and receive antenna, a new reference level shall be taken at the required separation distance. At a minimum, each window and door assembly

shall constitute a planewave test point. Every shield penetration shall constitute a planewave test point. When shield penetrations are within close proximity to each other, they may be combined into one test point, if the owner concurs. All walls, floors and ceilings shall be thoroughly tested.

b. *Equipment* - Test equipment shall meet the requirements of IEEE-Std-299 and this specification. This includes dynamic range and calibration requirements. At a minimum, the following equipment will be required for the testing.

- Tunable dipoles for 150 MHz to 1 GHz planewave measurements
- Near field probes for joint leakage tests
- Synthesized signal source and receiver (30 MHz to 2 GHz)
- Two horn antennas capable of covering 1-2 GHz
- Tripods
- RF cables

c. *Test Schedule* - When the shielding is completed, but prior to the point the shielding is no longer accessible for repair or modification, preliminary testing shall be performed in accordance with the procedures described below. When the entire project is completed, final acceptance testing shall be conducted.

d. The contractor shall submit a preliminary SE test plan for owner review and approval, 60 days prior to testing. The preliminary plan shall include the following:

- proposed location of each IEEE-Std-299 test point
- data record sheets
- sketches to show antenna positioning
- Sketches and description of reference level measurement
- equipment list and calibration dates

Within two weeks of receipt of the preliminary test plan, the owner will provide comments. 30 days prior to testing, the owner and contractor will reach concurrence and the contractor will submit a final test plan. Note that a separate test plan will be required for preliminary and final acceptance testing. Also note that to some extent, compliance during final acceptance may be determined by analysis and inspection per the results of the preliminary testing. However, this would require the concurrence of the owner.



13. Documentation

Prior to owner acceptance, the contractor shall deliver updated documentation covering every component of the shielded enclosure as follows:

- a. parts and materials lists
- b. manufacturers' data sheets and MSDS for all parts and material
- c. maintenance schedule, procedures, supplies and special tools
- d. suggested spares list
- e. diagrams showing all associated wiring and plumbing
- f. mechanical drawings, suitable for fabrication of all non-COTS items
- g. test plans and reports
- h. architectural drawings of the complete enclosure with description and location of all penetrations.

14. Certification of Compliance - Prior to owner acceptance, the contractor shall certify:

- a. That the enclosure design complies in every respect with the provisions of this specification and other applicable documents.
- b. That the enclosure has been constructed to accepted commercial standards with proper clearances and fits.
- c. That previously published or set ratings have not been revised by the contractor without prior written approval of the manufacturer of the actual unit and the concurrence of the owner.
- d. That the enclosure is complete, and that every part thereof is suitable for the intended purpose and capable of long term, maintenance free (except as noted) operation in its environment.
- e. That the documentation provided is complete, accurate and fully representative of the product delivered to the owner.
- f. That complete, fair and accurate test results have been provided to the owner.

15. Final Owner Acceptance - Upon successful completion of acceptance testing and certification of compliance the enclosure will be "accepted" by the owner.

16. Followup Testing - After acceptance, the owner may conduct follow up testing at regular intervals during the warranty period. If degradation in shielding effectiveness of more than 5 dB

at any point is detected, or if the shielding effectiveness falls below the specification level, the contractor will be notified and will be required to repair the deficiency. The contractor may request and finance independent testing to verify the owner's findings if he so desires.

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