Deep Space Network Control Room Noise and Vibration Study

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Vibration and noise levels in two of the DSN Deep Space Station (DSS) Operations Rooms have been an annoyance to personnel and are the suspected cause of tracking equipment failures. Measured noise levels were compared to Standard Noise Level Criteria curves. Precision instrumentation was used to measure noise and vibration levels in the rooms and equipment racks. Findings resulting from analysis of the measured data coupled with on-site noise reduction tests are discussed.

I. Introduction

At Deep Space Stations (DSSs) 11 and 61/63, existing vibration and noise levels have been an annoyance to personnel and are the suspected cause of tracking equipment failures. This study included on-site inspection and measurements to identify the noise and vibration sources and the related sound pressure levels, data analysis, and recommendations to reduce noise and vibration levels.

II. Measurement Criteria

Noise Criteria (NC) curves are commonly used to evaluate noise in buildings and are plotted against a background of measured sound pressure level vs frequency coordinates. A maximum noise criteria value of 55 (NC-55) is recommended for the Station Monitor and Control area in the Operations Room. At levels above NC-55, it is difficult to conduct telephone conversations and for operators to talk directly to each other if they are separated by a distance of more than a few feet. For comparison, in a typical private office, NC-35 or less is recommended.

A specified criteria for measuring vibration levels was not considered for rack and cabinet-mounted equipment in the Operations area. The goal was to reduce the vibration to an acceptable level by straightforward means, i.e. vibration damping and isolation.

III. Noise and Vibration Measurements

Airborne noise levels were compared to Standard NC curves to evaluate noise levels measured in the plenum space. Measured vibration levels radiated from fan enclosures were also converted to sound pressure levels and plotted vs NC curves. Additionally, a single sound meter reading in dBa was determined for each spectrum; the sound meter reading describes the response of the human ear. The sound meter readings were also used to compare the impact of fan noise with noise from other equipment in the Operations area where speech communication is important.

Figure 1, Curve No. 1, shows the range of noise (sound pressure levels), measured one meter from the discharge of

three Westinghouse draw-through-type Air Handling Units (AHU-2, AHU-3, and AHU-4) located in the plenum at DSS 61/63. Two of the three units, AHU-2 and AHU-3, operate continuously. Presently, AHU-4 is not used (except during adverse conditions when maximum cooling is required) because of its location directly beneath the Station Monitor and Control area. Figure 1, Curve No. 2, shows the range of noise levels radiated from the three fan enclosures. Figure 2 compared dBa sound meter readings in the Station Monitor and Control area of the Operations Room with AHU-3 and AHU-4 operating together and with AHU-2 and AHU-4 operating together. The difference in sound level measurements ranged between 2 and 7 dBa at various operator positions.

As an on-site experiment, AHU-2 fan noise was considerably reduced when an experimental plywood duct lined with 25-mm, semirigid glass fiberboard was placed in front of the air handler output. The noise reduction achieved by this experiment (10 dBa sound meter reading) is compared with existing conditions in Fig. 1, Curve No. 3.

At DSS 11, precision sound level instruments were utilized to measure vibration acceleration levels in the equipment racks. For example, muffin fan measurements were taken at the top of Telemetry Processor Assembly No. 2. This was the worst-case unit that could be located by inspection. Measurements with the fan on and the fan off confirmed that the muffin fan generated the most significant vibration in this particular rack.

Figure 3 compares vibration measurements of upper and lower Wangco Tape Recorders at DSS 61/63. These units are supported only at the front of the cabinet with the entire casing cantilevered. All measurements were made in the middle of the rear panels where vibration acceleration levels were greatest.

For the Diablo Disk Units, measurements for vibration were made at the rear of the horizontal sliding support tracks. Figure 4 shows the levels measured for the Diablo Disk Drive Unit at the top rear panel.

Figure 4 also displays the average vibration levels measured on the Wangco vacuum pump housing and its integrally attached hardware at DSS 61/63. This entire unit is supported by three rubber mounts at the rear of the cabinet. This allows the cantilevered front left corner to be relatively free to move and is the location where the measurements were made.

DSS 61/63 Operations Room Lobby floor is also impacted by vibrating mechanical equipment and associated piping in the Mechanical Room below. Piping that leads to compressors is rigidly hung from the concrete floor slab above and this produces a condition that is particularly annoying to people standing in the lobby area.

IV. Findings

Analysis of the measured data, coupled with on-site noise reduction tests, indicated that prefabricated sound attenuators or silencers in conjunction with duct work lined with a glass-fiber duct liner attached at the fan discharge should be installed on the three air handlers located in the Operations Room plenum at DSS 61/63.

Because of the air distribution and total volume requirements, silencers with low static pressure drops are required. It is estimated that the static pressure drop for each AHU, due to silencers only, will be about 5 mm to 8 mm for a 1-m-long silencer. The existing AHUs' capacities can compensate for these static pressure drops.

The estimated values of noise reduction at the AHU-3 duct output (29-dBa sound meter reading) for these improvements are shown on Fig. 1, Curve No. 4.

Vibration acceleration levels in the equipment racks indicated improper isolation of vibrating cabinet-mounted instruments and cooling fans. Contributing paths were established. Measurements with the fan on and fan off confirmed that the muffin fan generated the most significant vibration in the racks.

V. Action Planned

A. Air Handling Units

A design concept developed jointly by DSN support and station personnel for implementing the plenum air handler noise and vibration suppression technique described in Section IV was detailed. Requests for implementation bids have been solicited from local Spanish heating and venting contractors. It is expected the modifications will be completed during the second quarter of FY 80.

B. Muffin Fans

To reduce vibration, a 5-mm heavy metal ring will be mounted between the fan and the cabinet and securely fastened. This should provide additional stiffness and add mass to dampen fan vibration. To reduce airborne noise levels, a commercially available preformed glass fiber cylindrical duct will be placed over the fan. This device will be located in the line of sight between the fan and operator positions and should provide some fan noise reduction due to absorption.

C. Diablo Disk Units

All rack supports and associated connections will be stiffened. All tracks will be aligned vertically and any horizontal adjustments will be made at the cabinet mounts to ensure proper tolerance between tracks. Connections and mounting hardware joining the tracks to the angles which support the Diablo Disk Unit are to be made as tight as possible.

D. Wangco Tape Recorder Drive

Consideration will be given to mounting a horizontal angle support spanning the entire cabinet width near the rear of the unit. This will provide significant additional stiffness to these recorders and reduce the vibration levels associated with these units.

E. Wangco Vacuum Pump

Attaching horizontal angle supports to the existing front metal flange, just above the fan, and an anchor to each cabinet sidewall should provide maximum vibration reduction for the vacuum pump. Alternately, adding a support similar to the existing hard rubber mounts between the cantilevered front left corner of the pump and the cabinet sidewall would reduce vibration.

F. Pipe Hangers

To isolate existing compressor vibrations from the lobby floor at DSS 61/63 Operations Building, a series of spring hangers with 2.54-cm static deflection located as close to the underside of the floor slab as possible should be attached to the overhead pipe hangers (recommended Type PC-30 by Mason Industries, or equivalent by Amber/Booth or CalDyn).

V. Conclusion

By using precision instrumentation, equipment generating excessive noise and vibration in a DSS Control Room can be identified and measured. Corrective engineering action then can be taken to reduce the noise and vibration to acceptable levels. The air handler, muffin fans, Diablo Disk Unit, Wangco Tape Recorder Drive, and Wangco Vacuum Pump were identified as the sources of annoyance and corrective actions have been initiated.

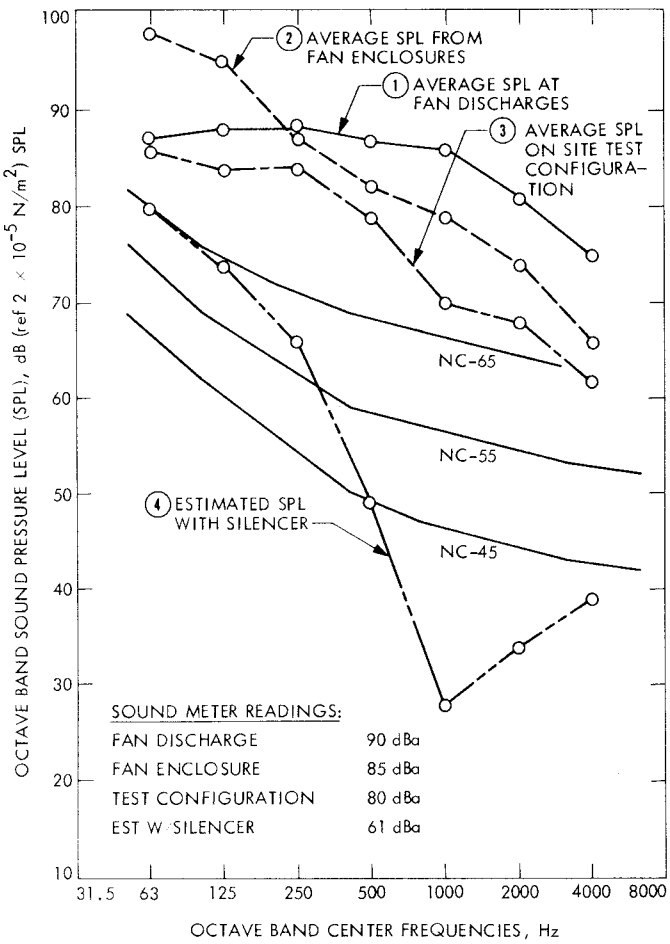

Fig. 1. Fan noise levels in plenum

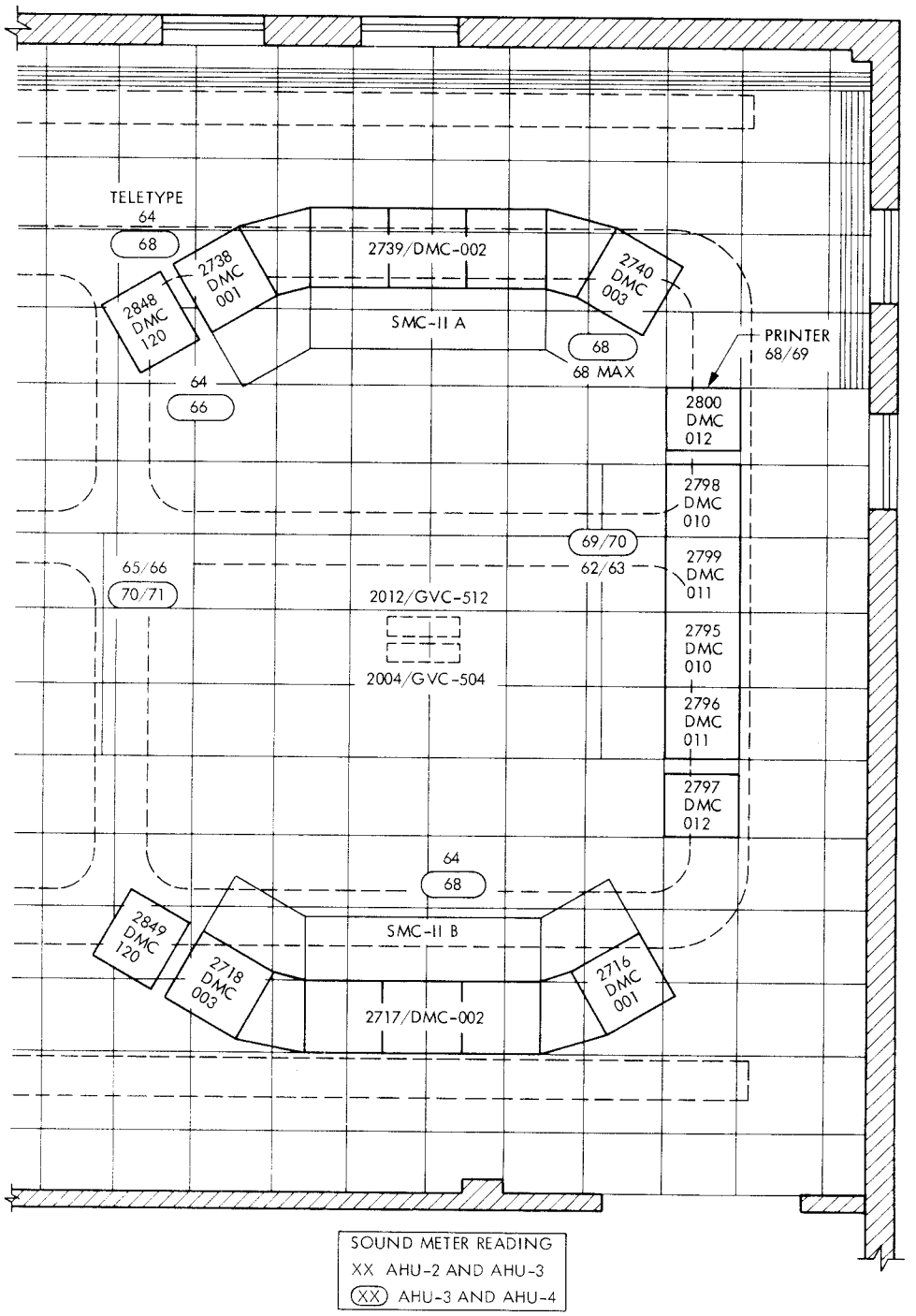

Fig. 2. Noise levels (dBa) in Monitor and Control area

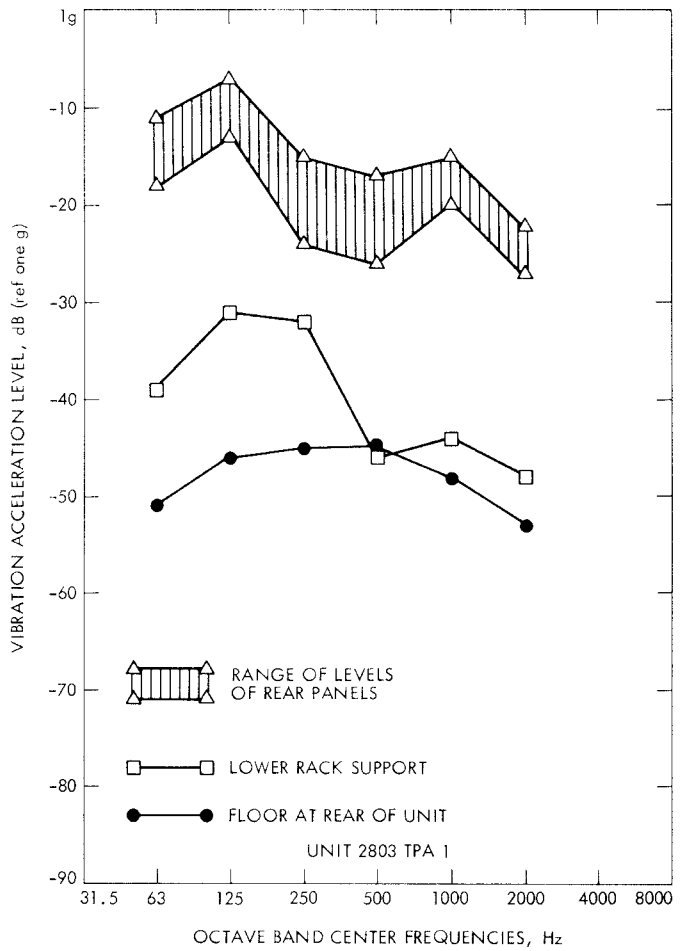

Fig. 3. Vibration levels at Wangco Magnetic Tape Recorder

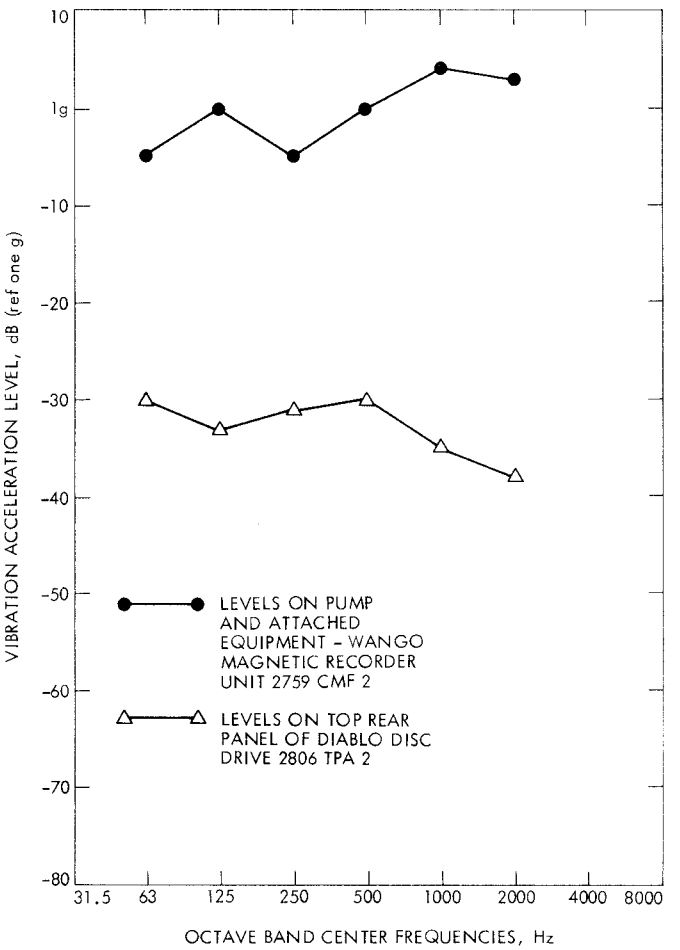

Fig. 4. Vibration levels at vacuum pump/Diablo Disk Unit