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December 18, 1985

Mr. James G. Keppler
Regional Administrator
U.S. Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Dresden Station Unit 2
Snubber Monitoring Program
NRC Docket No. 50-237

Reference (a): Dresden Inspection Report No. 50-237/85-034

Dear Mr. Keppler:

The referenced inspection report addressed the results of Mr. I. T. Yin's inspection of activities related to the Dresden Unit 2 Main Steam Transient Monitoring System. Section 3 of the report identified three documents which we provided to Mr. Yin to facilitate the discussions on the current status of the monitoring equipment. Attached to this letter are updated copies of those documents which describe the current monitoring system, the recently implemented LVDT trip limits, and our planned enhanced system.

Attachment 1: Gould-Vishay System Description
Attachment 2: Snubber Displacement LVDT Trip Limits
Attachment 3: Megadac Data Acquisition System

These documents are provided for your information.

Sincerely,

J. R. Wojnarowski

J. R. Wojnarowski
Nuclear Licensing Administrator

lm

cc: NRC Resident Inspector - Dresden

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DRESDEN-2 MAIN STEAM LINE SNUBBER MONITORING SYSTEM
GOULD-VISHAY SYSTEM DESCRIPTION

This document describes the Dresden-2 Main Steam Line Snubber Monitoring System and addresses the spurious trip problems experienced by the system.

SYSTEM DESCRIPTION

PURPOSE. – The purpose of the main steam line snubber monitoring system is to detect any event which causes large loads on the drywell main steam snubbers, to alert station personnel of such an event, and to record the snubber force and displacement time-histories for later analysis.

Six main steam snubbers are instrumented with one force and one displacement sensor each (see Figure 1). The six instrumented snubbers were selected from those which were previously damaged.

FORCE SENSORS. – Each force sensor is a strain gage bridge affixed to the surface of a snubber endcap, its output voltage calibrated against applied snubber force. Commercially available force transducers were not selected because of time constraints.

In all piping system transient testing, force sensors are the primary tool for quantifying system response. Restraint force time-histories provide a direct indication of transient severity. They also provide a load exposure history for the monitored snubber. Thus, the force sensors are the ideal and most vital sensors in the snubber monitoring program. They will detect and quantify transient load severity; they will detect and quantify thermal expansion in case of snubber overtravel (due, perhaps, to pipe bowing); and, in case of snubber failure 'frozen', they will indicate high loads during a temperature change.

DISPLACEMENT SENSORS. – Each displacement sensor is a linear variable differential transformer (LVDT) mounted on and parallel to the snubber, to measure its extension. LVDTs were chosen because S&L and Wyle had used them with success on previous projects.

DISPLACEMENT SENSORS, continued. -

Snubber displacement sensors (LVDTs) are used to monitor the current snubber position. Their output data aids assessment of snubber functional status during thermal expansion and dynamic transient events. If a snubber force was found slowly increasing past trip level, the LVDT data could confirm that the snubber failed frozen, and was not displacing during a piping temperature (expansion) change. If pipe bowing occured, causing large loads by fully extending or compressing a snubber, the LVDT data would indicate the cause. Finally, during dynamic load events, the LVDT data can be used to determine if the snubber is functioning properly, or if it is failed 'loose,' indicated by accelerations greater than 0.02 g's and near-zero measured snubber forces.

CABLES, PENETRATION, SIGNAL CONDITIONING. - The sensor excitation and signal wires run from the snubbers, through a penetration, to the test shed located outside the drywell.

There was almost no option in the choice of penetration; very few are available for low-level (millivolt) signals. The sensor cable shield is not carried through the penetration. This break in shield continuity worsens signal grounding problems and exposes the sensor signals to electrical noise from inside and outside the penetration. These failings contribute largely to system false trips.

Replacement of the existing penetration with a more modern design is not currently considered to be a cost-effective method for reducing false trips. Such replacement is very expensive. Replacement parts, custom-built to fit Dresden's now non-standard size penetrations, have a lead time greater than three months. Installation, rewiring and testing time would require several more months. Integrated leak rate testing, normally required only three times a decade and last done less than a year ago, would have to be done again specifically to qualify the new installation.

Further, penetration noise signals have been studied extensively and are now readily identifiable. The penetration noise signals have a very short duration, and thus it is extremely unlikely that they could obscure a true snubber event data recording. Thus, false trips caused by penetration noise do not pose a significant threat to real event detection.

CABLES, PENETRATION, SIGNAL CONDITIONING, continued -

Inside the test shed, the twisted-shielded pair wires connect to the Vishay signal conditioning system. It supplies the sensor excitation voltages, and amplifies the sensor output signals. Vishay is the standard DC signal conditioning equipment used by Wyle Laboratories for strain gage and LVDT installations (Wyle was the instrumentation subcontractor).

The amplified sensor signals then pass through active 130hz low-pass filters. They are designed to filter out high-frequency noise, but allow signals with frequencies in the piping response range to pass unimpeded. They were installed after discovery of the electrical noise as a partially successful attempt to eliminate false trips.

GOULD RECORDERS. - The signals then pass to two Gould waveform recorders. Each Gould recorder comprises amplifiers, triggering circuitry, digital memory and eight-pen thermal plotters. The recorders were chosen because they could continuously and reliably monitor the force and displacement signals at a high sampling rate, plot the recorded data automatically, and reset to continue monitoring. The recorders have pre-triggering capability; i.e., they continuously store data, so that when tripped, they can plot the data recorded just prior to the trip, as well as post-trip data. Another factor promoting the Gould selection was their availability and their ease of use: they were in stock, and their installation was relatively simple and fast. These qualities were necessary to meet a strict schedule.

The six force sensors are monitored using a Series 2800S Gould waveform recorder. It has one amplify / trigger / memory module per force sensor, for a total of six modules. Each module's trigger level is set to trip when snubber load exceeds 15000 pounds. The modules' triggers are interconnected so that if any channel triggers on a high snubber force, all channels record (and plot) data.

The six displacement sensors are monitored using a Series 2800W Gould waveform recorder. The 2800W has a single trigger, tripped when any of the 2800S channels trip. Thus, LVDT data is recorded when any snubber load trips the snubber force recorder; but the LVDTs themselves cannot trip the system. (Note: the trip configuration was changed in October, 1985. The 2800W was replaced by a 2800S, so that the system now can trip off of LVDTs and force transducers.)

RECOGNIZING ELECTRICAL NOISE

NOISE PROBLEMS AND SOLUTIONS. - Soon after the monitoring system was installed, significant electrical noise was discovered in the system. The noise level often exceeded the one volt trip level (the electrical level corresponding to 15000 pounds at the snubber). Thus, spurious trips have become a common occurence.

Noise sources include EM and RF interference transmitted through the air, through the amplifiers' and recorders' ac line current, and at the penetration. Turning on and off light switches and air conditioners in the test shed trip the system; communication radios activated near the shed produce enough electrical noise to peg the recorder pens off scale; during scram, supplying power through the sensor penetration to devices inside containment can also push signals off scale.

Low-pass filters between the signal amplifiers and the Gould recorders were a mildly successful attempt to reduce the amount of above-trip-level noise entering the Gould. To prevent ac line current noise effects, a voltage-regulating / spike-suppressing transformer supplies the ac power to the recorders and signal conditioning system. System wiring has been reviewed by experts from Gould and Wyle Laboratories, and various methods have been attempted to better ground the system. Tight wire-mesh screens have been mounted on the test shed windows to reduce RF and EM noise from nearby radios and relays. Further methods of noise reduction are constantly being evaluated, including replacement of signal conditioning equipment and recorders.

SIGNAL ANALYSIS. - Methods of determining whether a recording is of real data or of electrical noise are addressed below. All of this information has previously been recorded in Test Procedure 17652-2, or has been verbally communicated to responsible Dresden tech staff.

The signal analysis method has two parts. The first is to determine if the recorded snubber force and displacement signals could correspond to physically realizable pipe system behavior. The second, used after gaining experience in noise/signal recognition, is to compare new signal forms to previously identified noise signatures, and to correlate recording times to plant events known to cause significant electrical noise. This document addresses only Part 1; noise/signal recognition experience has been accumulated by the Dresden tech staff as a result of reviewing and analyzing the noise signals recorded on site.

GUIDELINES FOR RECOGNIZING A REAL EVENT. -

EVENT DURATION. - A transient snubber load is expected to last at least ten milliseconds. This estimated minimum duration is based on the force magnitudes involved and the dynamic characteristics of the piping systems, and is thus independent of transient source. Any shorter duration signal is therefore considered to be noise. Any recording that shows no signal is assumed to be of such short duration that the analog recording system could not indicate it, i.e., a duration of less than one millisecond.

CONTRASTING FORCE and DISPLACEMENT SIGNATURES. - When a snubber experiences load, that snubber's force and displacement sensors should show the snubber either

1 - in tension, and accelerating to full extension, or

2 - in compression, and accelerating to zero extension

The displacement sensor should reflect an initial movement with little or no associated force (see Figure 2), corresponding to the snubber internal free play, or 'dead zone.' After using up the 'dead zone,' displacement should slow, and then begin accelerating at less than 0.02 g's (see Figure 3) in the direction of the applied force.

Snubber displacement, if the snubber is not broken, should not increase with time any faster than s = 1/2 a.t.t

where a = 0.02 g = 7.72 in/sec/sec

t = time, seconds

s = snubber extension, inches

Thus, the snubber movement should not exceed one inch during a hypothetical half-second-duration one-directional force. This movement is independent of force magnitude, unless the force is sufficient to fail the snubber 'loose.' The force, on the other hand, may easily peak in less than fifty milliseconds, with no such 'acceleration' type limit on its magnitudes. (Note that if the snubber fails 'loose,' then it will not bear any load.)

The plot scales on the two Gould recorders are approximately fifteen thousand pounds per centimeter and one inch per centimeter. Thus, the magnitudes of the force and displacement time history plots, or 'signatures,' should appear very different from one another, along the lines stated above. The gross snubber extension should not change very quickly: any recording indicating large, instantaneous swings in snubber displacement should be considered noise. The snubber force may increase and decrease quickly, but the coresponding snubber displacements should be small, slowly accelerating changes. Thus, if the force and displacement recordings for a snubber are identical or very similar in form, magnitude and duration, then the recording should be considered noise.

SELF-CONSISTENT SINGLE LINE BEHAVIOR. - For lines C and D, which have more than one monitored snubber per line, each line's group of sensor outputs may be analyzed to determine if the pipe could be simultaneously exerting forces on the monitored snubbers as inferred by the data recording. For example, if the pipe would have to be moving in two different directions at once to load the snubbers as indicated by the recording, then that data can be dismissed as noise.

COINCIDENTAL LOAD AND DISPLACEMENT PHASING. - It is very unlikely or impossible for any transient to simultaneously load each snubber on each of three separate main steam lines; some finite time difference of load onset among lines B, C and D is expected. This applies to a lesser extent to the sensors on a single line. Different snubber 'dead-zone' amounts and different local system responses indicate that the loads responses and displacement responses of different snubbers should have some phase difference.

Thus, any recording that shows a high degree of coincidence between forces and displacements is suspect proportional to the degree of coincidence of signal timing and shape.

DOCUMENT SUMMARY. - This document provides a description of the Dresden-2 main steam snubber monitoring system, addresses electrical noise problems and attempted solutions, and provides a summary of previously suggested methods for analyzing system-recorded data to identify false trips and spurious noise signals.

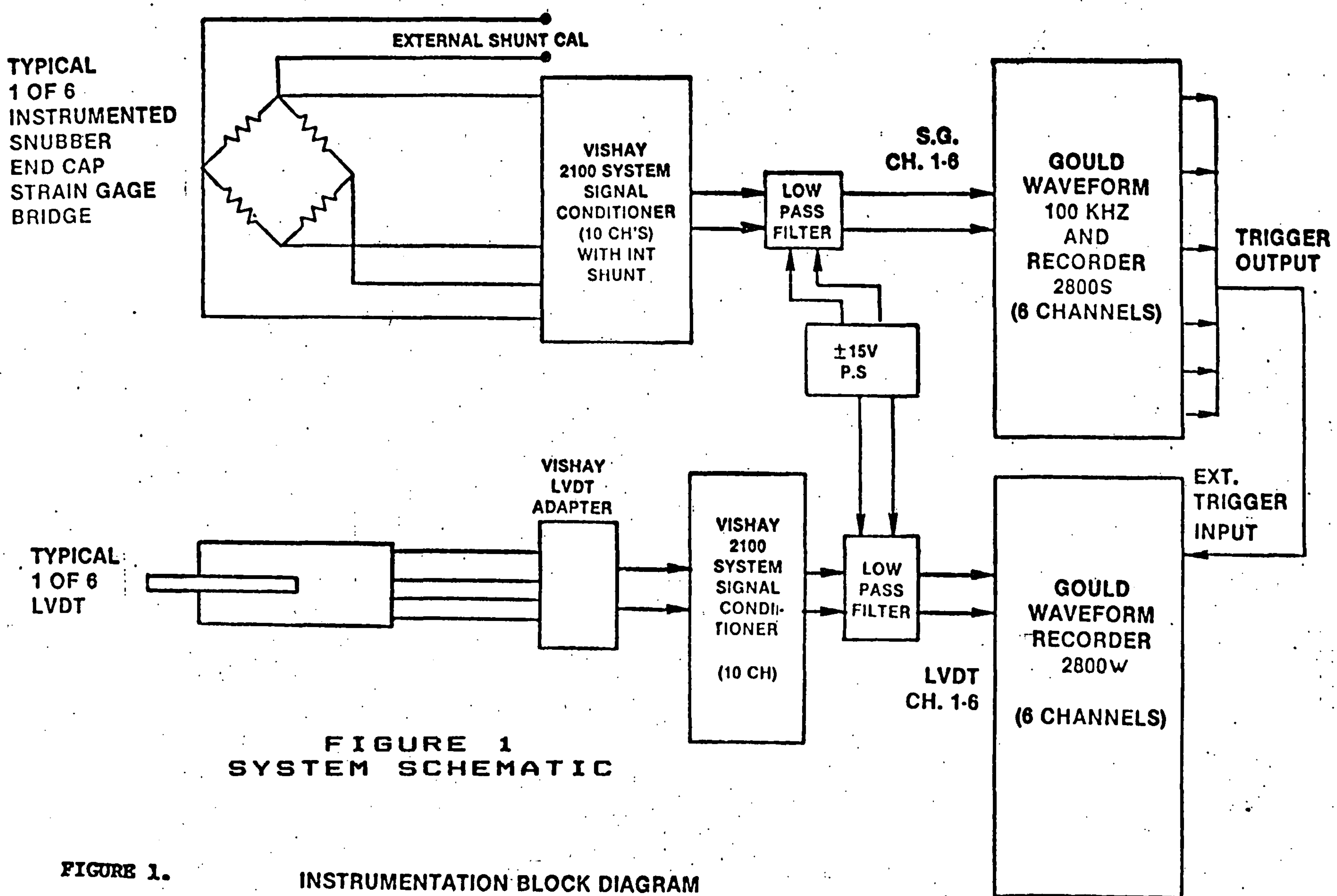

FIGURE 1
SYSTEM SCHEMATIC

FIGURE 1. INSTRUMENTATION BLOCK DIAGRAM FOR MAIN STEAM LINE SNUBBER MONITORING

(Note: the trip configuration was changed in October, 1985. The 2800W unit was replaced by a 2800S, with all trigger outputs tied together: now the system can trip off of LVDTs and force sensors.)

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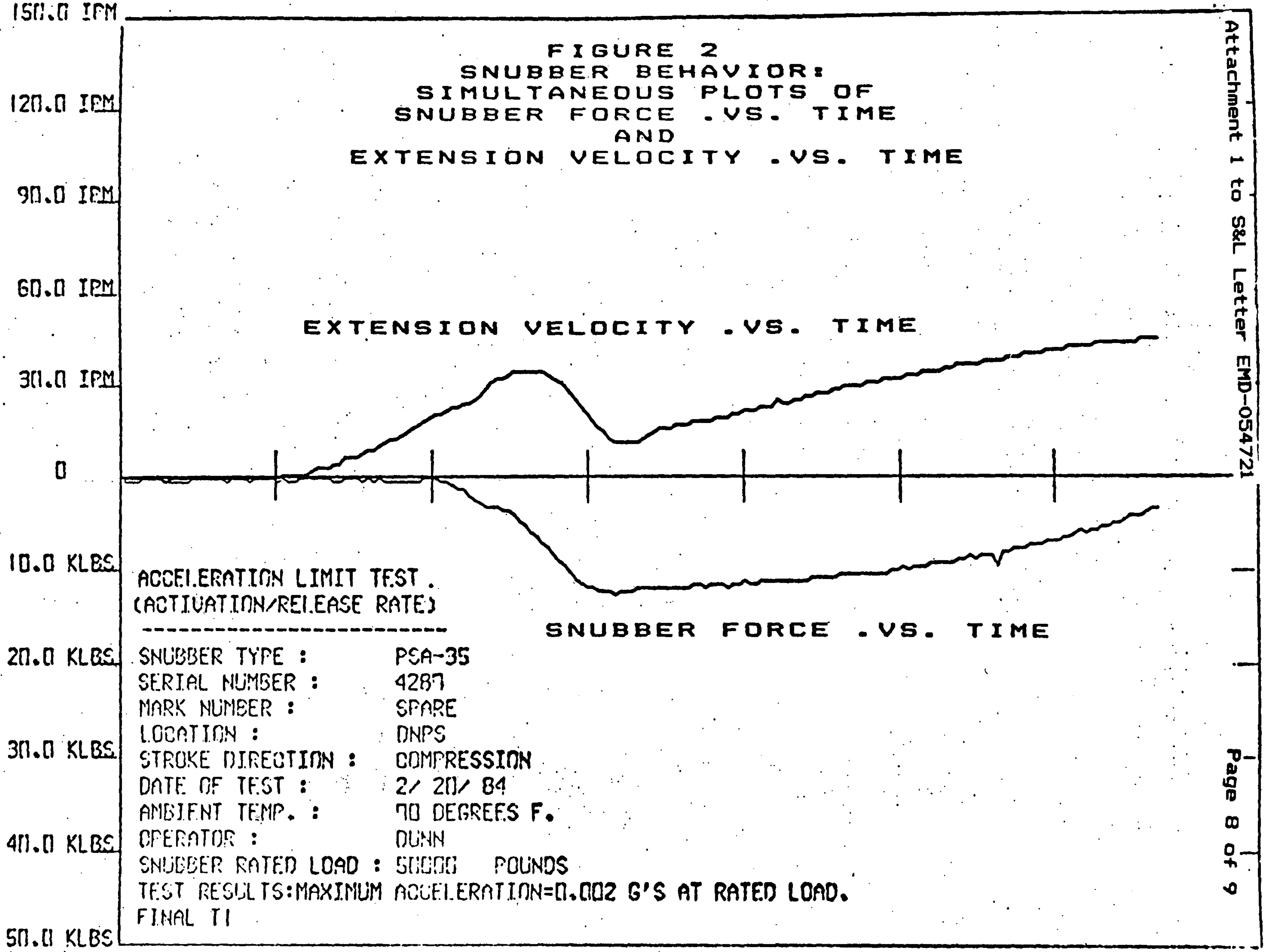
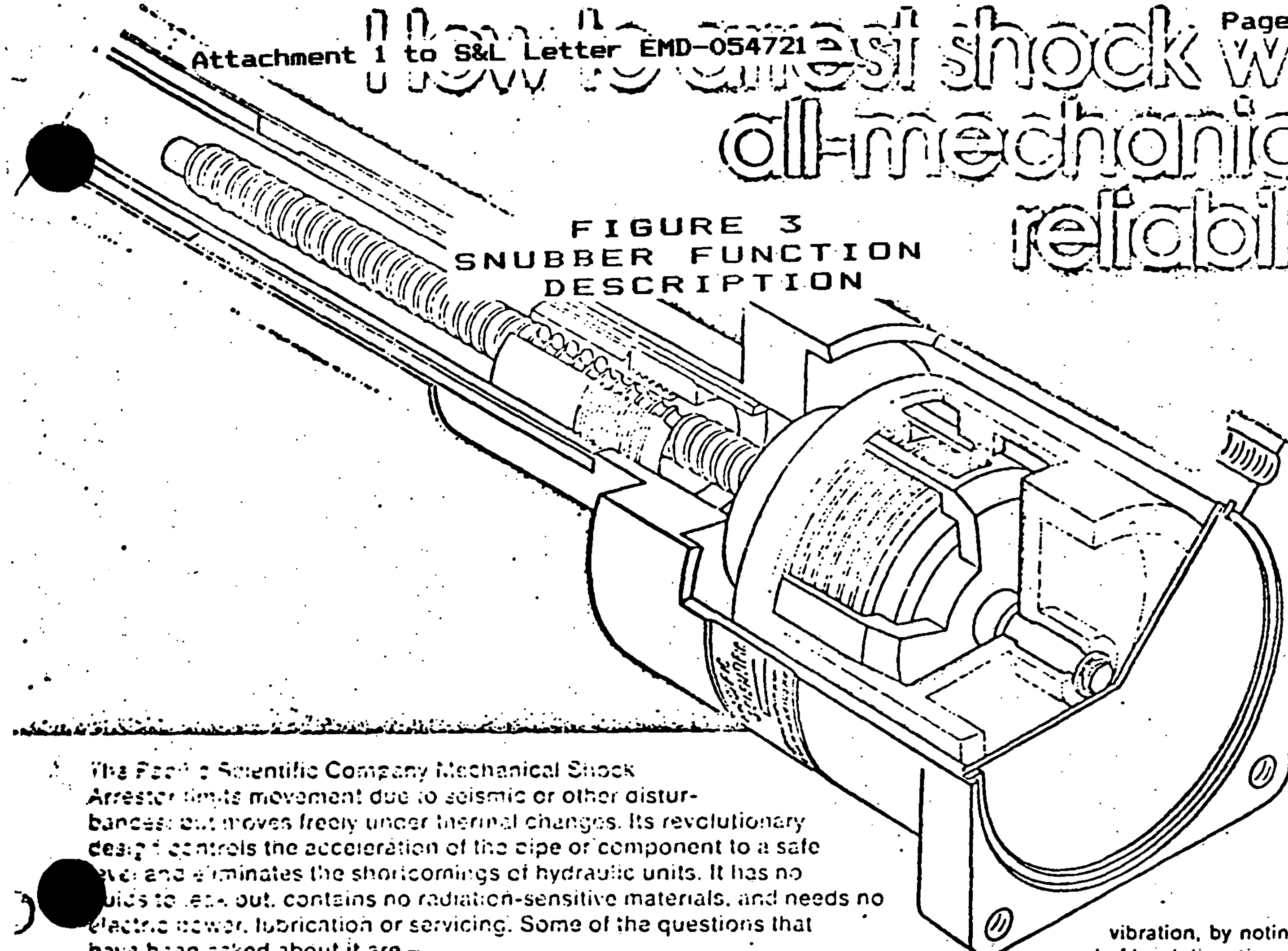


How to arrest shock with all-mechanical reliability

FIGURE 3
SNUBBER FUNCTION DESCRIPTION



The Pacific Scientific Company Mechanical Shock Arrestor limits movement due to seismic or other disturbances: but moves freely under thermal changes. Its revolutionary design controls the acceleration of the pipe or component to a safe level and eliminates the shortcomings of hydraulic units. It has no fluids to leak out, contains no radiation-sensitive materials, and needs no electric power, lubrication or servicing. Some of the questions that have been asked about it are –

HOW DOES IT WORK?

Any change in linear length of the shock arrestor is converted to rotary motion by means of a drive screw. The blue member is integral with this drive screw; and, by means of the ends of the orange capstan clutch spring which protrudes through it, turns the red inertia mass.

Seismic or abnormal disturbances compress or extend the shock arrestor which angularly accelerates the drive screw. The inertia of the red member resists turning. The resistance is applied to one end of the orange capstan, while the driving force of the screw is applied through the blue member at the other end of the capstan.

This actuates the capstan to tighten around the yellow mandrel thereby resisting the motion. This braking action will continuously throttle the motion to limit movement to the preset acceleration value. This preset acceleration is very repeatable because it is "designed in" by the spring rate of the capstan and inertia mass.

DOES IT LOCK UP?

[illegible], it does not lock up because if it did, it might become stuck. Then, thermal change could overload it and cause a failure in the piping system.

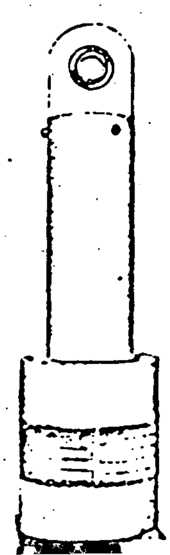
THEN, HOW CAN IT RESIST SEISMIC MOVEMENT?

Earthquakes are shakes, varying between 3 and 33 cycles per second. At these rates of reversal, the inertia mass applies and releases the brake to maintain the preset 0.02 g maximum acceleration in each direction. Within this cps range, the shock arrestor has very little movement. (See the time-displacement curve below.)

CAN I PREDICT OR MODEL ITS PERFORMANCE?

Yes!

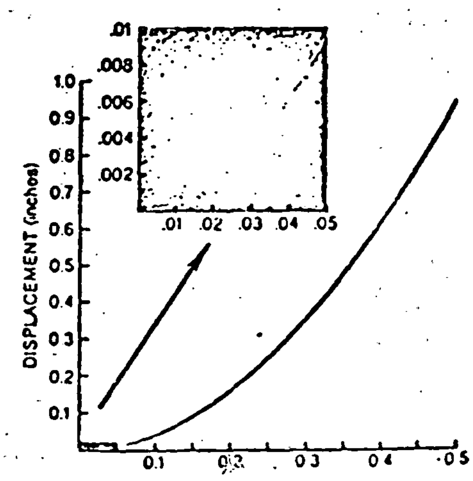
Its design and function are based on the classic formula for constant acceleration, $s = \frac{1}{2}at^2$, where "s" is displacement; "a" is acceleration and "t" is time. These shock arrestors are set to restrict the movement of the supported member to less than 0.02 g's or about 7.73 in/second squared.



Maximum allowed displacement can be found for cyclic loading, such as a seismic disturbance or vibration, by noting a reversal of load direction every half cycle. For example, in a 10 Hertz disturbance, the applied force would alternate direction 20 times per second so it would be acting continuously in one direction for .05 seconds.

Referring to the time-displacement curve below, it is seen that in 0.05 seconds, the displacement is less than 0.01 inches. This happens because the arrestor is sensitive only to acceleration. It is not load-sensitive. To completely define the arrestor's behavior, the free play in the bearings plus the spring rate of the shock arrestor should be included.

Information regarding the spring rates of various sizes and other acceleration limits for special applications is available upon request.



DRESDEN-2 MAIN STEAM LINE SNUBBER MONITORING SYSTEM: SNUBBER DISPLACEMENT LVDT TRIP LIMITS

PURPOSE.

This document addresses trip limits for the six linear variable differential transformers monitoring the positions of six main steam line snubbers.

BACKGROUND.

The existing monitoring system constantly monitors forces acting on six main steam snubbers; when the force on any snubber exceeds fifteen thousand pounds, the system automatically records ten seconds of snubber force and snubber position (snubber extension) data.

Per CAL requirements, the system is being upgraded so that it can trip when displacements exceed trip limits, as well as when forces exceed trip limits. This document summarizes the displacement trip limits and their derivation, and addresses system operating procedure revisions needed to implement the new trip limits.

CALCULATION SUMMARY.

The following summarizes S&L calculation EMD-054632, which will derive the snubber displacement trip levels. Derived trip levels are reviewed; reasons for not applying report or shutdown trip levels to snubber displacement data are provided; uses of displacement data are reviewed, to again demonstrate why report and shutdown limits are not considered applicable for displacement data; trip level conclusions are reviewed; and finally, system operating procedure revisions, needed to implement displacement criteria, are addressed.

TRIP LEVELS. - Calculations to determine appropriate trip, report and shutdown limits reveal that the relationship between snubber displacement and transient load severity is complex, indirect, and often inconclusive. However, trip levels are derived. The suggested trip level is plus-minus 1" surrounding the snubber displacement steady-state value (which depends on current pipe temperature).

REPORT AND SHUTDOWN LEVELS. - Because the relationship between snubber displacement and transient severity is so tenuous, report and shutdown levels are not considered applicable. Any displacement number can be conservative in one scenario, and unconservative in another. The following sections show why.

DISPLACEMENT VERSUS LOAD DURATION. - Snubber displacement is more closely related to load duration than to load magnitude. Functional testing of a snubber verifies that snubber acceleration is less than 0.02 g's; this test relates snubber displacement to load duration, not to load magnitude. The acceleration test (barring damaging load magnitudes) is approximately independent of load magnitude.

A snubber may, for example, withstand a twenty-millisecond load of thirty thousand pounds, and show a 70 mil displacement. Likewise, it may experience a two-hundred millisecond load of three thousand pounds, and show a 150 mil displacement.

Thus, a one hundred mil criteria would not trip on a thirty-kip load, but would trip on a long-duration three kip load. A potentially damaging load is ignored; a minor, low-risk load is detected.

DISPLACEMENT VERSUS LOAD DIRECTION CHANGES. - Snubber displacement is also nonlinearly related to the frequency of load direction changes. A one-directional load will increase the snubber displacement at a constant acceleration; if maintained for more than half a second, the snubber extension may exceed an inch.

If, however, the load shifts direction every fifty milliseconds (corresponding to a ten hertz forcing function), then the maximum displacement should be less than one hundred mils. The shifts in direction never allow the snubber's 7.72 in/sec/sec acceleration limit to result in a large snubber extension velocity or displacement.

Thus, depending on frequency of load direction changes, a half-second load may result in a an over-one-inch displacement, or in an under-one-tenth-inch movement.

USES OF DISPLACEMENT DATA. - The intended uses of snubber displacement data are reviewed here, to demonstrate that displacement data only augments the snubber force data.

Snubber displacement data is helpful in determining the condition of a snubber. A transient event recording is similar to an on-site snubber functional test: the displacement data indicate whether the snubber accelerations are exceeding the 0.02g functional test criteria. The displacement data will also confirm that the snubber is freely extending and contracting during pipe thermal expansion and contraction periods.

The displacement data also helps in determining whether an event is real or caused by electrical noise. Snubber displacement and snubber force time histories should have dissimilar Gould plot magnitudes and should not act perfectly in phase. Noise-caused recordings tend to have identical phasing on all channels, and a random magnitude and frequency response. Thus, the displacement channels help to differentiate between real event recordings and false trip / noise recordings.

Adding trip ability to the snubber displacement channels may in some eventuality catch an event that the force sensors would miss. However, in most such hypothesized cases it is necessarily assumed that one or more force sensors are malfunctioning, or that one or more snubbers have already failed 'loose,' allowing displacement but exerting no measurable force, or that the hypothesized damaging transient loads have some very unusual characteristics.

CONCLUSIONS REGARDING DISPLACEMENT TRIP LEVELS. – Our decision to use displacement sensors is sound. Their data helps to detect false trips, to confirm real events, and to assess snubber function during thermal expansion and transient events.

Our decision to add trip ability to the displacement channels may, under isolated circumstances, result in the detection of an otherwise undetected event. It may also, however, increase the number of false trips. This problem could overwhelm any hypothesized gain from tripping off of displacement channels.

However, trip levels are derived. The plus-minus 1" limit surrounding snubber position equilibrium is based on practical considerations, but in part supported by stress analysis.

Practical considerations determined the displacement trip levels. Experience has shown that electrical noise levels often exceed force trip levels, which correspond to about one volt at the Gould waveform recorders. The one inch displacement trip levels also correspond to one volt at the Gould recorder. That there will now be six more trip circuits exposed to the random noise may in itself double the number of false trips, posing a greater threat than gain to real event detection.

Should this be the case, it is recommended that the displacement trip circuits be shut off, and that the system functionally return to its current configuration, tripping only off of over-fifteen-kip snubber forces.

A piping stress analysis of MS Line C was done, enforcing a one inch displacement at the location and in the direction of one of the monitored snubbers. Predicted stresses were below ten thousand psi. This result is assumed typical of all six monitored snubbers. This provides some evidence that a one inch displacement at a snubber will not of itself prove a pipe overstress exists. However, if the snubber functions properly, a severe transient event could cause stresses over ten thousand psi, and show a snubber displacement of less than one hundred mils. Thus no analysis result can override the fact that there is no direct correlation between load severity and snubber displacement.

OPERATING PROCEDURE REVISIONS. - Because the allowable trip limit (plus-minus 1") is less than the expected pipe thermal expansion and contraction movements during heatup and shutdown (up to 2"), it will be necessary to turn off the triggers of the snubber displacement channels during large temperature changes, to avoid constant false tripping. After temperature equilibrium is reached, the trip levels can be set relative to the new snubber positions, and the triggers can be turned back on. A revision to the system operating procedure should reflect these actions.

Also, the panel switches are different: the switches on the new displacement recorder will now be almost identical (most notably excepting trip level settings) to the original force recorder. The revised system operating procedure must also reflect this change.

GOULD TRIP LEVEL LIMITATIONS. - Further, it should be noted that the Gould recorders do not provide an 'offset trip window.' Therefore, the limit checking can only be done on one side of the displacement equilibrium position. That is, the trip point can be set to be at 1" greater snubber extension than equilibrium, or 1" less snubber extension that equilibrium, but not both. (It is considered that the trip point should be on that side closest to a snubber end-of-travel, to detect motion tending to take the snubber past its design travel range.)

SUMMARY.

Trip limits are plus-minus 1" surrounding the equilibrium position of a snubber. The limits are based on practical considerations: adding the displacement trip ability with one inch limits may double the number of false trips, threatening detection of actual events. A smaller limit could render the system useless. Piping stress analysis of a typical monitored line indicates that piping system flexibility is sufficient to accomodate a one inch displacement in the snubbers' vicinities.

Report and shutdown limits are not considered applicable to displacement data. There is no direct relationship between transient load severity and snubber displacement. Snubber displacement data alone is not a sufficent basis for assessing the importance of an event.

All recorded data, whether tripped by force or displacement limit exceedence, should be analyzed as before: report and shutdown limits are based on force sensor limits. To determine if an event has occurred, or if the trip was caused by noise, the existing noise recognition procedures can be used. To determine event severity, force and displacement data should be analyzed as outlined in existing procedures, with no revision required.

If the system is installed, and the number of false trips significantly increases, it is recommended that the displacement trip capability be turned off. It is considered that the possible gain of having displacement trip ability is overshadowed by the possibility of losing an actual event in a forest of false trips.

Existing operating procedures should be revised to incorporate the displacement trip limit setting procedures outlined above, and to account for the difference in front panels between the old and the new displacement recorders.

DRESDEN-2 MAIN STEAM LINE SNUBBER MONITORING SYSTEM: MEGADAC DATA ACQUISITION SYSTEM

PURPOSE.

This document describes the Megadac data acquisition system, its advantages over the current data acquisition system, and a summary of the major steps involved in installing the Megadac system.

SYSTEM OVERVIEW.

The Megadac-based system will have two parts, as shown in Figures 1 and 2. The first is the data acquisition part, located in the reactor building. It will monitor all incoming sensor data, automatically recording all sensors' outputs when any trip level is exceeded. The data is recorded on removable cartridge tapes. The second part of the system is the data reduction part, located in the administration building. It will be used to analyze the data recorded on the cartridges.

The data acquisition system will be connected to the force and displacement sensors monitoring the six main steam line snubbers. The heart of the system, the Megadac mainframe, will be in the test shed. It contains signal conditioning, trip logic, digital memory and a read/write cartridge tape drive. An annunciator (a 117-volt relay box controlled by the Megadac trip circuitry) will be connected to a lamp; the lamp will light if the system has tripped, informing site personnel that trip data is recorded on the unit's tape cartridge. An assigned person will remove the cartridge, install a fresh one, and reset the annunciator.

The recorded data will be carried to the adminstration building tech staff offices, where a Megadac cartridge tape reader is connected to an IBM microcomputer, a printer and a plotter. Opus software, designed to process Megadac data using an IBM microcomputer, will allow the user to transfer the tape data to the IBM microcomputer's hard disc. Once the data is on disc, it can be quickly analyzed by the user using preprogrammed plotting routines.

Any portion of the force or displacement data can be plotted on screen, printer or plotter; several channels can be overlaid to assess time phasing or waveform similarities. Data can be stored on floppy discs, plotted on an 11" x 17" color plotter, or tabulated on a dot matrix printer.

PART 1: DATA ACQUISITION

The Megadac mainframe unit contains signal conditioning, trip logic and digital recording circuitry. These three parts of the mainframe unit are addressed below. Advantages of the Megadac system relative to the current Gould-Vishay data acquisition system are noted.

SIGNAL CONDITIONING.

The Megadac mainframe can provide up to twelve volts DC excitation for the force and displacement sensors, and up to eight-hundred-fold amplification for the returning millivolt-level sensor signals.

The strain-gage-bridge force sensors receive their excitation directly from the Megadac, and their outputs return directly to the Megadac to be amplified, filtered, and passed to the trigger and recorder logic.

The LVDT displacement sensors require AC excitation and produce AC outputs, and thus require excitation modulator / signal demodulator conversion boxes in order to function with the Megadac's DC excitation and amplification circuitry. These conversion boxes are currently used with the Vishay system (which also uses DC circuitry), and are the only component of the Gould/Vishay system that will remain with the Megadac system.

Other than the LVDT conversion boxes, the signal conditioning circuitry is all internal to the Megadac mainframe housing.

Advantages relative to the existing system:

1) Compatibility: the signal conditioning circuitry and filters are compatible with the digital recording portion of the Megadac; grounding is simpler, less troublesome.
2) Noise resistance: the single, unitized Megadac mainframe metal housing will reduce system susceptibility to local EMI and RFI noise sources.
3) Calibration: sensor excitation levels, signal zeroing and other calibration features are computer-regulated, simplifying system operation and maintenance.
4) Ruggedness: the Megadac system is designed for field surveillance work.

TRIP LOGIC.

The Megadac will sample each sensor's output one thousand times per second, and compare each sample to predetermined high and low trip limits. If desired, the Megadac can be programmed to trip only when the trip limits are exceeded for a predetermined consecutive number of samples.

To reduce false trips, it is proposed that the Dresden system be set to trip when the trip limits are exceeded for three consecutive samples, i.e., the signal level remains high for three milliseconds. This is consistant with the current system whose trip response time is very fast (on the order of hundredths of milliseconds) but whose analog plotter cannot plot (at current settings) any blip with less than a 2.5 millisecond duration.

Advantages relative to the existing system:
1) Trip window limits need not be equal plus and minus; thus offset (from zero) windows can be established around the displacement (LVDT) signals, as well as the force (strain gage) signals, to account for unequal tension and compression calibrations
2) Consecutive-sample-high trip control will allow automatic rejection of brief noise spike false trips

DIGITAL RECORDING.

The Megadac will be set to record at one thousand samples a second for each sensor. The recorder has pretrigger, meaning that it will save data recorded prior to the trip. This is done by constantly recording data in internal memory; when a trip is detected, the internally recorded pre-trip data is dumped onto tape along with the post-trip data.

The Megadac will be set to record three seconds of pre-trip data and nine seconds post-trip data. A Megadac cartridge tape can hold more than twenty minutes of data (at one thousand samples per second for twelve channels), thus can store more than one hundred trips per tape. Because the system has a large (512 Kbyte) internal memory buffer, the system should have no 'dead time' as it plays data out to the cartridge tape unless there are a large number of consecutive trips.

Advantages relative to the existing system:
1) No system deadtime (Gould is 'dead' during thermal plotting of previous trip).
2) More flexible specification of record time and sampling speeds; tape cartridge stores more data than paper roll.
3) Advantages of digital recording are most easily seen in the advantages of digital data reduction, addressed in the following section.

PART 2: DATA REDUCTION

In the Adminstration Building tech staff offices there will be a Megadac cartridge tape reader attached to an IBM microcomputer system. Opus software, designed for Megadac transient data reduction, resides on the IBM hard disc.

When a cartridge tape containing trip data is loaded into the Megadac tape reader, the Opus software can transfer the trip data onto the IBM hard disc.

Once the data is on the hard disc, the user can plot out the data from each channel for the full twelve second duration. If it appears that the data could indicate a real event, he may more closely analyze that portion of the twelve second recording containing the transient data, expanding the time scale until the individual millisecond sampling points become distinct on the screen.

To analyze relative phasing and waveform shapes of sensor outputs, he can overlay up to five sensors onone plot. For example, he can overlay a force recording from line B onto one from line D; if the load onset is simultaneous, and the waveform similar, the signal is probably noise (to be verified by other checks). Or, he can overlay the force and displacement from one snubber; if the waveforms are too similar, or if the LVDT does not show some initial displacement prior to load onset, or if the force shows compression loading but the displacement shows the snubber extending, then the signal is probably noise. Also, plots of previously identified noise events may be overlayed onto new data, to determine similarities or differences.

Advantages relative to the existing system:

1) Improved data presentation:
   - time scale expansion
   - amplitude scale expansion
   - plot overlays
2) Improved data handling:
   - self-contained tape cartridges, rather than hundreds of feet of rolled paper

MEGADAC INSTALLATION.

The following is a summary of the major steps involved in installing the Megadac system at Dresden.

(S&L)
Familiarization: with the IBM PC AT operating system, OPUS software, MEGADAC mainframe software, sensor wiring and calibration.

(S&L)
Configuration: configuring system libraries in both Megadac-internal and Opus software packages

(S&L)
Procedures: drafting the following procedures:
1 - system installation
2 - calibration
3 - operation
4 - data analysis
5 - maintenance

(CECo)
Procedures: reformatting above procedures

(S&L,CECo)
Transport: ship unit back to site

(CECo,S&L)
Familiarization: CECo personnel familiarization: guided by S&L and Optim trainers

(CECo,S&L)
Installation: (into reactor building); wiring; debugging; calibrating; quantifying noise levels; considering effects of noise on trip levels (higher or lower); working on noise problems

(CECo,S&L)
Testing: (depends on plant condition at time of installation)

SUMMARY.

The Megadac system has a number of advantages over the existing Gould-Vishay data acquisition system. Self-contained, with high-speed sampling and programmable triggering capability, it is uniquely qualified for the Dresden snubber surveillance.

FIGURE 1: DATA ACQUISITION

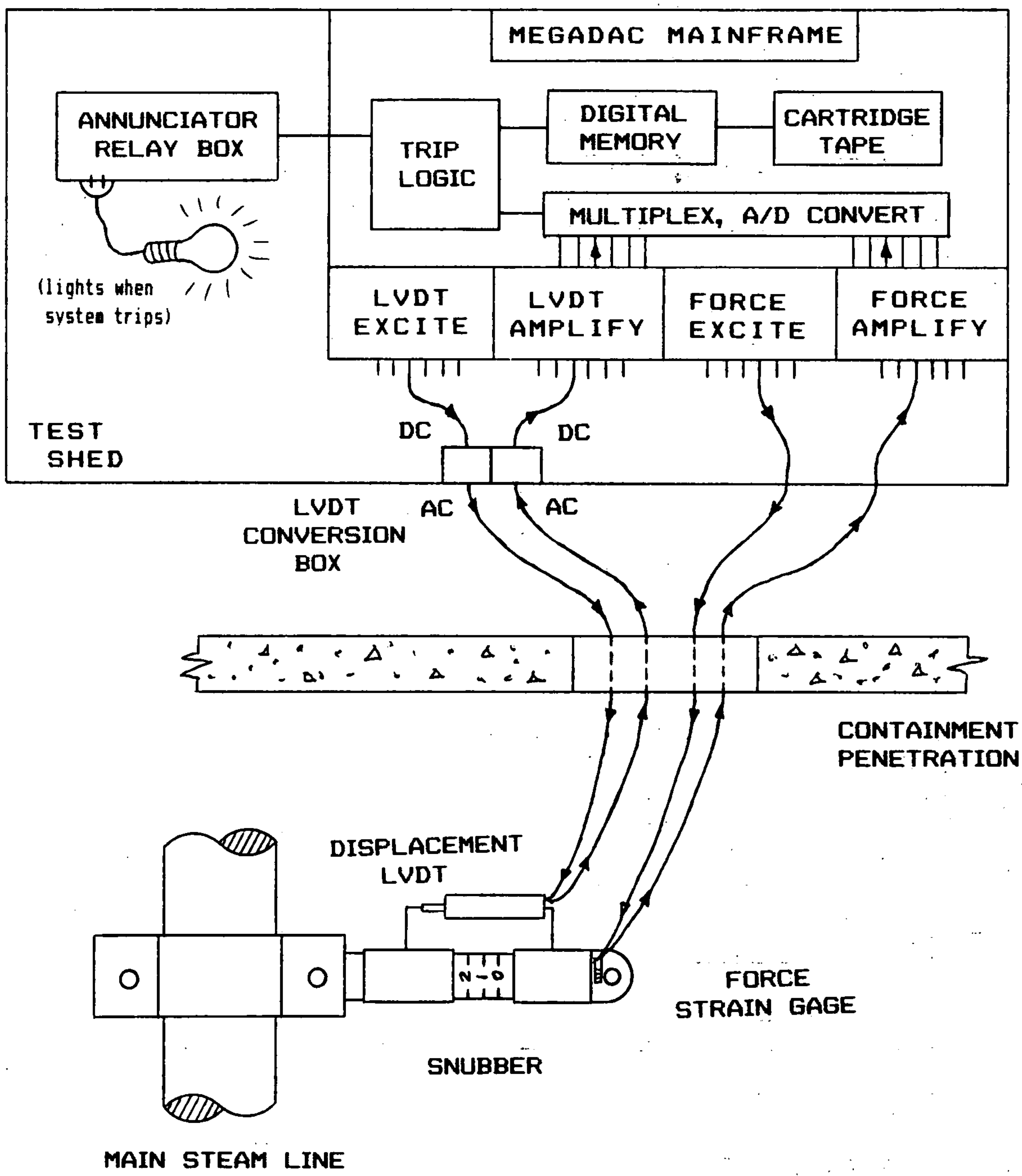


FIGURE 2: DATA REDUCTION