V. 6

Sept 1965

#9-65-348

MAINTENANCE DATA - HOW AND WHAT

This presentation is concerned with how maintenance data can be collected, what can be done with it and possibly a few arguments why it should be of any concern.

In reviewing some of the papers written by others involved in the maintenance function I get the feeling that even though the organizational structure dictates an operation unique within our own companies, we all have some common problems brought about by some fundamental and basic requirements. Therefore, possibly a more appropriate title would have been "Problems" of Instrumentation Maintenance. However, I am certain that all of our problems will not be solved in this conference and in the limited time it will be possible to consider only a few of them.

Some of the common problems associated with Research & Development Departments and in particular with Government contracts are related to the requirements imposed by the customer. Anyone working on Government contracts will be familiar with MIL Handbook 52, NASA Quality Publication NPC 200-2 and MIL-C-45662A. In these publications are contained the requirements for contractors quality programs necessary to ensure that the work will meet the requirements of the Government contract.

Not only are the requirements called out but these documents also provide information and guidance to Department of Defense personnel concerned with the evaluation of the contractors calibration and maintenance system.

For the sake of those who may not be familiar with these documents I want to review briefly some of the contents of NPC 200-2:

In General

The contractor shall provide for the selection, evaluation, approval, maintenance and control of all inspection standards, gages, measuring and test equipment necessary to determine conformance with specification, drawing and contract requirements.

All measuring and test equipment should be calibrated at scheduled intervals against certified standards which have known valid relationships to national standards. The due date or other identification attesting the due date of the next calibration shall be displayed on each item of measuring and test equipment.

Calibration standards laboratories shall maintain temperature, humidity, and dust controls comparable with the accuracy and design characteristics of the standards involved.

Within state-of-the-art limitations the standards used for measuring and test equipment shall have a tolerance no greater than 10% of the allowable tolerance for the equipment being calibrated.

The contractor shall periodically inspect, maintain and recalibrate all measuring and test equipment. The intervals for each equipment shall depend upon the use, accuracy, type of equipment, required precision and other conditions affecting measurement control. Procedures shall include provisions for removal from service of any equipment that has not been maintained or recalibrated in accordance with eatablished schedules.

Records shall be maintained on the recalibration status, condition and corrections or repairs for each inspection of measuring and test equipment. Variables data shall be maintained and analysis performed to determine trends of wear, deterioration, and adequacy of maintenance. Procedures shall be realistically revised accordingly.

To further elaborate on this item Handbook 52 states: "adjustment or assignment of calibration intervals should be done in such a way that a minimum of 95% of equipment or standards of the same type are within tolerance when they are submitted for their regularly scheduled recalibration. (i.e.) If more than 5% of a particular type of equipment is out of tolerance at the end of its interval, the interval should be shortened." The fixed interval concept of recalling instruments for service and calibration is a device which has been almost universally adopted and which has merits, including convenience. However, by the use of fixed intervals alone I don't believe we are going to get the most out of our instrumentation, because in some critical areas it is necessary to verify the instrumentation calibration timewise, as close to the test as possible. This is usually done by an on-site pre-or-post calibration or both. With only a fixed interval concept, the interval would of necessity be so short as to be impractical or the validity of the measurement may not be known until the instrumentation has been through its scheduled service. Therefore rather than fixed intervals alone, I believe it is going to take a combination of practices to attain the maximum utilization of our instrumentation. I believe others are recognizing this inadequacy and are taking some action, as evidenced by the appearance of papers describing such systems as:

1. APC (which stands for Assured Performance Calibration). This is a program in which the instrument is calibrated in place, or checked on the line, so to speak, on very short intervals. The instrument remains in service until a calibration indicates something is changing. Any instrument out of a particular variety that demonstrates poor reliability is removed from service and will not return to service until it has been completely rehabilitated.

2. Another system is "Selective Calibration" where a piece of equipment is calibrated only within the range of its intended use.

3. Another is Automatic Recall for calibration of measurement standards.

4. Another is On Site calibration.

5. Another is MSA (Measurement Systems Analysis).

There are also others which have been conceived in an attempt to improve our instrumentation. I believe each of these systems have merits but as I mentioned earlier, it may take a combination of these systems to do the job. But which ones? That is the big question. I think it can be answered properly only after the facts are available on which to base decisions. These facts, I believe can be established only after instrumentation data has been accumulated and analyzed.

At Rocketdyne in the Field Laboratories alone, over the past 15 years, we have seen the number of instruments increase from possibly a few dozen to over 35,000 on which Service history cards were maintained. Hand entries were made by the technician. In the beginning when the files contained only a few cards they were fairly easy to maintain, however as the number of instruments increased, the problem of maintaining the history files seemed to increase at an even faster rate. It gradually occurred to us there was considerable non-productive effort being expended on making entries on the history cards and maintaining the files. At this point no doubt some of you would ask the same question we did. "why are we keeping these records?" These are some of the justifications we came up with:

1. The information can be helpful in servicing the instrument.
2. The last service date can be determined along with the number of times it has been serviced and for what reason.
3. With a record of parts replaced and the man-hours spent, the cost of maintenance could be figured.
4. General deficiencies and inadequacies of instrumentation components could be detected.
5. The history cards could also serve as an inventory record.

6. There were several other arguments, but probably the most convincing argument, as I pointed out in my opening remarks, was that one of our customers, the U.S. Government, requires that "records be maintained on the recalibration status, and corrective action or repairs made for each instrument. Also variable data must be maintained and analysis performed to determine trends of wear, deterioration and adequacy of maintenance."

Based on these arguments it appeared that the history cards could be justified. And generally speaking the history cards fulfilled the requirements of the customer and contained the information with which the other arguments could be satisfied. However, there still remained the problem of utilizing this data. It is not sufficient to have the data available, it must be processed and analyzed to make it useful. To process the history card information required that each card be individually handled, and each item tabulated separately. After some lengthy and tedious attempts to analyze the data contained on the history cards, it was pretty generally agreed that some better way to analyze the data must be found.

Following a thorough investigation of automatic data processing systems, since this has become such a widely accepted means of analyzing large quantities of data rapidly and inexpensively, it was decided to automate our history card data. Rocketdyne is now in the process of adapting an automatic data processing system to its instrumentation reliability program which will include over 80,000 instruments.

This system is called CRIS, which stands for Calibration, Recall and Information System. Contained in CRIS are:

1. The method by which measuring and test equipment is recalled for periodic calibration and/or service.

(2) The method for recording and accumulating historical data such as:

a) hours required in performing each type of job (e.g., Calibration, Service, Repair or other)

b) average hours for each job

c) parts cost for each repair and average parts cost per instrument.

d) tolerance conditions of instrument prior to and after calibration and,

e) the percent of times the instrument is within tolerance.

Weekly performance data that lists the hours and parts costs on the instruments processed through each laboratory during each week is provided. The length of time each instrument is at the laboratory is computed and reported as turn-around time.

Each week a forecast of the following four week workload for each laboratory is provided. Yearly forecasts are also available.

CRIS provides the following services:

1. A master inventory list of all items requiring calibration and/or service

2. One week advance notice to the using department

3. A weekly Past Due Tabulation of all items not received by the due date

4. A history tabulation of all work performed

5. A forecast tabulation of scheduled calibration or service

6. Special Evaluation tabulation by instrument, type, class or model

7. Automatic tabulation of scheduled work:

   a) By laboratory assigned to perform the work
   b) By department owning the equipment
   c) By category of equipment
   d) By standards required

8. Data for forecasting funding requirements:
   a) Total units requiring calibration/service
   b) Total hours required
   c) Cycles per year
   d) Total hours per year

9. Data for proposing new contracts:
   a) Average hours per cycle
   b) Average hours per category
   c) Average cost per repair
   d) Average repairs per cycle
   e) Average repairs per category

Upon request, CRIS may also provide data for special reports and studies, e.g., items held for repair, items sent to outside agency for calibration, or repair; items out-of-service, in shelf, in storage; items on loan; and items which cannot be located and need followup.

Special category tabulations show items always within tolerance limits, always outside tolerance limits, repaired items, and repair cost.

Through data processing reports in the CRIS program, forecasts may be made. Some of these include information obtained from the following:

1. Automatic tabulation, detailed listing of scheduled work:
   a) By laboratory to perform the work
   b) By department owning the instrument
   c) By category of equipment
   d) Four-week forecast provided each week

2. Tabular data provides total units requiring calibration, total hours to perform calibration, cycles per year, total hours per year, and average hours per unit or cycle.

3. Provides data for vendor rating by instrument type, category manufacturer, and percent reject.

4. Provides data for work performance rating including average hours in or out-of-tolerance, physical condition, and technician number.

Before this information can be extracted from the system certain information must be entered. This briefly is how it is done. Once an instrument has been established in the system the basic input and control document is the Calibration/Service Requisition Form, (a sample is shown) which consists of 1 sheet of card stock, perforated to form 4 separate parts or cards of standard sizes. When an instrument is sent to the laboratory for calibration or service the using department will attach this form to the instrument and retain section No. 1 as a receipt. The calibration or servicing agency will perform the calibration or service as necessary, entering the required information in section No. 2 in coded form. When completed, section No. 2 will be forwarded to the Data Processing department for key punching. Upon completion of the calibration or service, the instrument will be returned to the submitting department by the calibration agency. The calibrating agency will retain receipt No. 2. Section No. 4 serves as a traveler and will remain with the instrument until returned to the using department.

There are two situations that will cause the Calibration/Service Requisition to be generated. The first situation is when the instrument is due for recalibration or routine service. In this case all of the basic description of the instrument and the due date will be printed in the appropriate spaces automatically by the data processing system, two weeks in advance of the due date to allow for processing and mailing. The requisitions will then be sent to the using department which has only to write in the information called for below line 3 of Section 4, attach the form to the instrument and route it to the servicing agency.

The second situation for which the Calibration/Service Requisition will be generated is when an instrument is sent in for repair. In this case the using department will use a blank form and enter only the property number of the instrument in the spaces provided and complete the information called for below line 3 on Section No. 4. When the form runs through the system, the rest of the identifying information will be added to the card by the system from the detailed description associated with the property number. Various checks and proofs are built into the system so that erroneous entries are prevented.

CRIS primarily provides for the recalibration and servicing of measuring and test equipment. Secondly it is a management tool which provides for monitoring various critical areas relative to performance of calibration, service and repair activities all on a very current basis. CRIS will now provide us with the capability of accumulating and rapidly analyzing instrumentation service and reliability data.

As Instrument Maintenance men, we are faced with the problem of maintaining instrumentation to a high degree of reliability in order to get better measurements with lower costs. The squeeze is on! It is going to require that we take a close look at our instrumentation maintenance methods. Those instruments which are unreliable and expensive to maintain are going to have to go. And those inefficient methods of maintenance are going to have to go with them.

ITEM NO. (1)	TYPE (2)	PROPERTY NO. (3)	DESCRIPTION (4)	MODEL NO. (5)	MFR. (6)	DEPT. & GROUP (7)	BLDG. (8)	LOC. (9)	DUE DATE (10)	OP.	LAB. (11)
AE10346	T	SN-7928	CAPACITOR-STD	1409-L	GEB	0733	325	75	04235	C	B3

CALIBRATION / SERVICE REQUISITION

(12) REQUISITION NO. B- 132064

CONSOLE NO. (13)	CATEGORY (14)	FILE (15)	G.O (16)	INT. (17)	PROC. (18)	NO. TESTS (19)	% IN (20)	TREND (21) 1	2	3	4
	010.02	S-164		30		1	100	1			

REQUESTED BY (22) | DATE (23) | (24) LBR CHG NO | DEPT BY 25 | LEDA ACCT 26 | CONTRACT 27 | SUB ACCT 28 | STAT 1 29 | STAT 2 30 | STAT 3 31

APPROVED BY (32) | PHONE (33) | 34 MTRL CHG NO

WAS USED IN 35 (PROPELLANT) | INTENDED USE RANGE 36 (FLOWRATE, PSI, ETC.) | SERVICE FOR USE IN 37 (PROPELLANT)

TMR No 38

FAILED ☐ (39)
1. INCIDENT
2. IN USE
3. ANTA CHECK
4 OTHER

DESCRIBE ALL DEFECTS AND MALFUNCTIONS (40)

LIST ALL ACCESSORIES INCLUDED (42)

RETURN DATE REQUIRED 43

ROUTING (41)

DEPT	BLDG
1.	
2	
3	
4	

ITEM NO. (1)	PROPERTY NO. (2)
AE10346	SN-7928

MFR. (4) GEB | (3) REQUISITION NO. B- 132064

DESCRIPTION (5) CAPACITOR-STD

MODEL NO. (6) 1409-L | BLDG. (7) 257

RECEIVED BY (8)

DEPT. & GRP. | EXTENSION

CLOCK NO. (11) | DATE (12)

5

ITEM NO. (1)	TYPE (2)	PROPERTY NO.	DESCRIPTION (4)	MODEL NO. (5)	MFR. (6)	DEPT. & GROUP (7)	BLDG. (8)	LOC. (9)	DUE DATE (10)	OP.	LAB. (11)
AE10346	T	SN-7928	CAPACITOR-STD	1409-L	GEB	0733	325	75	04235	C	B3

CALIBRATION / SERVICE REQUISITION

(12) REQUISITION NO. B- 132064

FOLLOWING DATA WILL BE KEY PUNCHED - PLEASE WRITE CLEARLY

HOURS REQUIRED: CAL. (13) | SERV. (14) | REPAIR (15) | OTHER (16) | CODE | PC. (17) | TOL IN / OUT (18) | PARTS COST (19) | F.C. (20)

DATES: RECEIVED (21) MO. DAY YR. | RELEASED (22) MO. DAY YR. | COMPLETED (23) MO. DAY YR.

RECALL DATE MO. DAY (24) YR. | OP. (25) | REVISED INT. (26) PR. (27) | G.O. (28) | STAMP (29) | STANDARDS USED (31) (32) (33) (34) (35) (36) (37) (38)

STANDARDS USED (39) (40) (41) (42) (43) (44) | TECHNICIAN'S NAME (30)

1. ☐ CALIBRATED
2. ☐ SERVICED
3. ☐ REPAIRED
4. ☐ CERT./REPT.
5. ☐ RELEASED
6. ☐ HOLD FOR PARTS

DATE

CLOCK NO.

REPAIRS MADE

ITEM NO. (1)	PROPERTY NO. (2)
AE10346	SN-7928

MFR. (4) GEB | (3) REQUISITION NO. B- 132064

DESCRIPTION (5) CAPACITOR-STD

MODEL NO. (6) 1409-L | BLDG. (7) 257

RECEIVED BY (8)

DEPT. & GRP. (9) | EXTENSION (10)

CLOCK NO. (11) | DATE (12)

2

129-C-4 REV. 8/65