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SPENT FUEL TEST-CLIMAX:
TECHNICAL MEASUREMENTS
DATA MANAGEMENT SYSTEM DESCRIPTION
AND
DATA PRESENTATION

R. C. Carlson

August 1985

Lawrence
Livermore
National
Laboratory

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MASTER

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by
R. C. Carlson

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SPENT FUEL TEST-CLIMAX:
TECHNICAL MEASUREMENTS
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ABSTRACT

The Spent Fuel Test-Climax (SFT-C) was located 420 m below surface in the Climax Stock granite on the Nevada Test Site. The test was conducted under the technical direction of the Lawrence Livermore National Laboratory (LLNL) as part of the Nevada Nuclear Waste Storage Investigations (NNWSI) for the U. S. Department of Energy (DOE). Eleven canisters of spent nuclear reactor fuel were emplaced, along with six electrical simulators, in April-May 1980. The spent fuel canisters were retrieved and the electrical simulators de-energized in March-April 1983. During the test, just over 1000 MW-hr of thermal energy was deposited in the site, causing temperature changes of 100 degrees Celsius near the canisters, and about 5 degrees in the tunnels.

More than 900 channels of geotechnical, seismological, and test status data were recorded on a nearly continuous basis for about 3-1/2 years, ending in September 1983. Most geotechnical instrumentation was known to be temperature sensitive, and thus would require temperature compensation before interpretation. Accordingly, a ten-inch reel of digital tape was off-loaded and shipped to Livermore every 4 to 8 weeks, where the data were verified, organized into 45 one-million-word files, and temperature corrected.

The purpose of this report is to document the receipt and processing of the data by LLNL Livermore personnel, present facts about the history of the instruments which may be important to the interpretation of the data, present the data themselves in graphical form for each instrument over its operating lifetime, document the forms and locations in which the data will be archived, and offer the data to the geotechnical community for future use in understanding and predicting the effects of the storage of heat-generating waste in hard rocks such as granite.

1.0 INTRODUCTION

The Office of Civilian Radioactive Waste Management (OCRWM) Program of the DOE sponsors research and development activities aimed at providing reliable long term isolation of commercial nuclear reactor wastes in geological repositories in a variety of host media. This large multidisciplinary program plans the creation of an operational repository in the 1990's. There will be few opportunities early in the program for field tests involving actual reactor waste.

One such opportunity has been exploited at the Nevada Test Site (NTS). Two existing facilities have been modified and used to conduct a test of packaging, transport, storage, and retrieval of a limited number of actual spent-reactor-fuel assemblies.

The first of these, the engine maintenance, assembly, and, disassembly (E-MAD) facility in southwestern NTS (originally developed for the nuclear rocket development program), had the capability to encapsulate spent fuel assemblies in canisters suitable for geologic storage. All of the remote-handling equipment and interim storage facilities needed to support a geologic storage test were established there in connection with DOE's Commercial Waste and Spent Fuel Packaging Program.

The second facility (consisting of underground construction originally built in the 1960's for weapons effects testing) provided access to an intrusive granitic rock mass (the Climax stock) at a depth comparable to that being considered for geologic storage. This site, located about 80 km (50 mi) from the E-MAD facility, required relatively little additional construction and rehabilitation to accommodate the SFT-C.

1.1 Objectives of the SFT-C

The overall objective of the SFT-C was to evaluate the feasibility of safe and reliable short-term storage of spent reactor fuel assemblies at a plausible repository depth in a typical repository rock, and to retrieve the

fuel afterwards (Ramspott, et al, 1979). An additional objective was to evaluate the difference--if any--between the effects of an actual radioactive waste canister and an electrically heated simulator. Furthermore, since the test involved the largest scale heating of a hard rock medium to date for a test of this type, a third objective was to collect data addressing two subjects: 1) The ultimate qualification of granitic rock as a medium for deep geological storage of high-level radioactive waste, and 2) the design of repositories in granitic or other hard rock, and the prediction of the response of such repositories to that waste.

The scientific objectives of the Technical Measurements Program were chosen to address the last two topics above, as follows:

- o Documentation of the response of the rock near the central drift to the mining of that drift, in terms of stress changes and displacements.
- o Comparison of that response to the results of existing computational models to assess the validity of those models in terms of mechanical effects alone.
- o Documentation of the temperature and radiation dose in the close-in zone to infer the total power output of the spent fuel assemblies and the proportion of that power transported out of the canisters by ionizing radiation as opposed to thermal transport.
- o Documentation of the displacement and stress response of the rock in the intermediate zone to the thermal disturbance of the fuel and heaters.
- o Comparison of the measured thermomechanical response to computational models, to assess the validity of those models.
- o Documentation of the relative amount of heat removed by ventilation.

- o Documentation of the thermal field (both close-in and intermediate) and comparison to computational models of heat transport.
- o Documentation of the relative effect of natural fracturing on the rock response.
- o Evaluation of existing geotechnical instrumentation under simulated repository conditions.
- o Because the data produced might one day be relevant to repository licensing proceedings under the NRC, all activities were subject to a Quality Assurance Plan approved by the DOE Nevada Operations Office (LLL Quality Assurance Plan - Spent Fuel Test, M-078-08, Revision 1, dated August 31, 1979).

1.2 Report Organization, Rationale

It is not the intent of this report to analyze or interpret the data, nor to collect and repeat all that has been said in other reports on the instruments' installation, calibration, and performance. What is intended is that this report provide the data, in an easily accessible form, to the geotechnical and waste storage communities at large, and to provide basic background information, or references thereto, necessary for the interpretation of the data. The "mineby" data, taken to satisfy the first two objectives of the previous section, was acquired by a separate data acquisition system and was reported elsewhere (Heuze et al., 1981), and so will be excluded here.

The report format will follow the data through the steps of receiving, screening, data base building, temperature correction, archiving, and plotting. The Q/A Plan referred to in the last objective of the preceding section requires thorough documentation of these activities, so the source of the parameters used, the algorithms applied, background information, and references will be given in some detail. Much of the needed reference information is contained in a relatively few documents: The Technical Concept (Ramspott et al., 1979), a series of Project Interim Reports (Carlson et al.,

1980; Patrick et al., 1982; Patrick et al., 1983; Patrick et al., 1984a), and three reports on instrument installation and performance (Brough and Patrick, 1982; Patrick, Carlson, and Rector, 1981; Patrick, Rector, and Scarafioti, 1984c). It is assumed that the reader is familiar with the Livermore Time Share System (LTSS), in particular, the XPORT utility for file transport and storage, and its directory structure (Smith and Belles, 1981).

1.3 Data Acquisition System

Before proceeding to the topic of data processing, some background information and definition of terms is necessary concerning the Data Acquisition System (DAS). Much of this is repeated in most of the documents referenced in Section 1.2.

The data acquisition task was shared fairly equally by two HP-1000 computer systems, called Node 100 and Node 200, which could monitor each others' status. Early in the test, if one computer went down, data from instruments assigned to that computer were lost. Later, additional hardware was incorporated and the computers were programmed so that the "healthy" machine would take over the other's load. Each computer controlled a HP digital voltmeter (DVM), and a bank of HP Scanners which could connect any one of about 500 instruments to the DVM, as selected by the computer. At the scanner level each active instrument was identified by a Physical Channel Number (PCN), i.e., the scanner channel to which the instrument was attached. Above the scanner level, the instruments were identified by their Logical Channel Number (LCN), which runs from 1-512 for Node 100 instruments, and 1001-1512 for Node 200. Since a given instrument might be moved from one scanner to another by wiring changes, each instrument was assigned a permanent six-character identifier, called the logical channel name, or License Plate. In order to properly associate the PCN, LCN, and License for each instrument, and to describe characteristics of the instrument needed for later processing, a descriptive data base was maintained. This data base controlled the scanning of the instruments, the conversion of raw data (volts, amps, ohms, etc.) to engineering units, and sending out alarms if the data were outside preset values. Even when an instrument was completely installed, no

data were obtained until the scanning tables in the data base were updated. Also, if the scanning tables were updated, but calibration or algorithm information was missing, the converted data would either be missing or erroneous. It was thus very important that the data base be promptly updated when instrument changes occurred.

When properly updated, the data base described the system at one particular point in time. The data base system had no provision for maintaining a history of changes to the system, and, at each update, previous values were lost. This was satisfactory for the operation of a real-time system, but makes it difficult to document, at a later date, what transpired. This had a major effect on the task of applying temperature corrections to the data in Livermore after the fact.

Since the test spanned several years, a system for measuring time was needed which did not involve the calendar date, with variable length months. The unit chosen was the Julian Day, with the two most significant digits removed to conserve space. In this system, January 1, 1980 is JD44240. Times were recorded in decimal fractions of a day, counting from noon, Greenwich Mean Time, with a precision of 0.00001 day.

2.0 DATA RECEIPT PROCESS

2.1 Tape Handling and Storage (TAPECOPY)

The digital magnetic tapes generated on the SFT-C Data Acquisition System (DAS) are 800 bpi, 9-track, odd parity, blocked with 174 logical records, of eleven 16-bit words each, per physical record (Nyholm, 1983, p 182). This record size is very nearly 512 60-bit words (one disk sector) on a CDC 7600 and allows efficient transfer onto the Livermore Time Sharing System (LTSS) via LTSS Utility Routine TAPECOPY. A complete description of the terminal dialog required to effect the transfer is given by Hage, 1983, on page 20. Each tape is assigned a tape vault slot when received, and once copied to disk, the tapes are stored in the LTSS tape vault, slots JC101-JC125, JC201-JC225, FB201, FB202, and MI401-MI425.

The tapes left the NTS with a label of the form "SFT-nnn" where nnn is a three digit sequence number assigned to the tape as it was off-loaded. When run as described in the reference, TAPECOPY produces a family of files, one for each file on the tape. The disk files were named TNNBxxx, where the NN are the last two digits of the NTS tape number, nnn, and xxx is a sequence number. An "end of file" (EOF) mark was written to tape every 24 hours, and the tapes were unloaded roughly every four to eight weeks, so tapes generally contained between 28 and 56 files, though tapes with as few as 9, and as many as 113 files were observed.

2.2 Data Screening (BREAD)

As mentioned in Section 2.1, The data as received are structured as logical records of eleven 16-bit words (Nyholm, 1983, p 93):

Word 1	Logical Channel Number (LCN), 16-bit integer
Words 2-4	Logical Channel Name (License plate), six 8-bit characters
Words 5-7	Julian time of record acquisition, 48-bit floating point

Words 8-9 Raw data value, 32-bit floating point

Words 10-11 HP converted data value, 32-bit floating point

The first step in screening the data for use on a CDC-7600 is to convert the 16-bit word structure of the HP to the 60-bit word structure of the 7600. The name of the program which does the screening, BREAD, takes its name from this process: Binary Read. BREAD reads a family of binary TNNBxxx files and produces an ASCII file named TNNAOCL, stopping when the file reaches 4240000 octal (1130436 decimal) words. The user changes the file name to one of the form SFnnnL/V, and restarts BREAD where it left off, eventually producing up to three ASCII files. In these S-file names, nnn is the same tape number as NN with a leading zero, L is an A, B, or C, indicating which of the files produced from tape NN this file is, and V is a revision indicator, incremented each time the file is modified. The S-files are sorted by license, then time, whereas the data on the tapes is in the order acquired. The Format of the S-files is I5,A6,F12.5,2E13.6 for LCN, License, Time, HP converted value, and raw data value, respectively.

The BREAD data sieve is quite complex, and is described in detail elsewhere (Hage, 1983). A brief description follows:

- 1) Check that the Logical Channel Number is between 1 and 512, or between 1001 and 1012.
- 2) Check if the channel is one selected for preemptory discard.
- 3) Check that the license is the proper one to be associated with the observed LCN.
- 4) Check that the license is of the correct form, i.e., 3 letters followed by 3 numbers. Have the license or the three character groups been seen before, or are they new?
- 5) Check that the time of the record is within the time range during which the tape was accumulating data.

- 6) Check that the raw data value is within the conceivable range for that instrument.
- 7) Check for time gaps of more than one day since the last record for this instrument.

BREAD combines all of the above checks to decide what action to take, depending also on options selected by the user. Five actions are possible, pass the record as correct, correct errors in either the LCN or license (not both), flag the record as questionable, preemptory discard, or delete the record for cause. The term preemptory discard refers to the discard of certain channels which were necessary for the safety and operational efficiency of the test, but which have little scientific value (e.g., radiation monitors, air samplers, etc.). These channels remain on the archived tapes and can be resurrected whenever desired, but their deletion here reduces later file sizes by almost 50%.

If data are deleted for cause, flagged, or corrected, a warning is placed in a message file named MSGS. With especially difficult tapes the message file had many thousands of entries. When BREAD was operated in its normal mode (with the "replace bad license", "correct bad channels", and "discard by time range" switches on, the flags "NC?", "ND?", "C?", or "NC?" were appended to the lines which caused "New License Numeric", "New License Alpha", "Bad Channel", or "Channel changed" errors. Lines with the "bad channel" flag, "C?", were generally total gibberish, although some looked like assembly listings or compiler maps for programs on the HP system. Occasionally a "gibberish" record would, by chance, have a number in the proper range for a LCN in the LCN field. In this case BREAD would "fix" the license, but the line would fail the raw data limits or the time range test, and be eliminated. The chance of a bogus record getting through the BREAD data sieve intact, without being flagged, is minimal.

BREAD also produces a statistics file named STAT, ordered by LCN, and giving the number of times each license occurred, the limits used to test the raw values, and the number of input records, output records, and errors found of each type, along with the earliest and latest times present in the input

and output files. At the beginning of the STAT file is a listing which gives the LCN and license of the first and last record in each file input, along with the number of physical and logical records in the file. When the input is a family of files from a tape, this list is compared with a similar listing produced at NTS when the tape was off-loaded.

In order to effectively screen the data, BREAD must know what the data are supposed to look like. Since the instruments and their LCN assignments changed as the SFT-C progressed, this information was not programmed into BREAD, but was placed in an ASCII Interface File, which could easily be modified as occasion demanded. The format of the file is described in Hage, 1983, pp 15-18. The file's name was SFTINTnn, where nn is a version number which ran from (blank) to 19. In addition, there were two files named SFTSPEC and SFTSPEC1, in which the data value limits were multiplied by one million to pass data recorded in microvolts instead of volts (see Section 2.3, SFIX).

In some cases, when we had advance notice of the addition of new instruments, or the moving of instruments from one channel to another, a new version of SFTINTnn was made prior to making the BREAD run. Other times, the sudden occurrence of many "new license numeric" errors (BREAD doing its job) was the first indication of the change. When this happened, the interface file would be updated after confirming the changes with DAS personnel, and the file would be rerun, incrementing its sequence number by one more each time. To keep track of which BREAD version and which interface version was being used on a file, these values were printed at the beginning of the MSGS and STAT files. This record is also kept in the project Quality Assurance (Q/A) files and is reproduced here as Table 2.2-1. The SFTINTnn files are stored on the mass store system in directory .SFT:BRDINT under user numbers 138000, 348500, 393200, and 760075.

In the process of data screening, a file (or family) was recursively fed through BREAD, checked by the author, or his designate, modified (if needed), and fed back through BREAD until the BREAD diagnostic files indicated a "clean" run. The output file was then stored in directory .SFT:S-FILES. The checking process was as follows:

- 1) On the first pass of a file family from a tape, the record listing produced by BREAD at the beginning of the STAT file was compared with the listing delivered with the tape to assure that all files and records were read. (Note: the NTS listing was somewhat unreliable in that lines could either be duplicated or missing.)
- 2) The STAT list was checked to see if any unexpected license names were present. This was indicated by a second license after the primary one obtained from the interface file. The list was also checked for anomalous high or low record counts in groups of instruments which should have been scanned at equal rates. It was also noted if the tape was all Node 100, all Node 200, or mixed.
- 3) The MSGS file was checked for errors which could be recoverable. Generally "range exceeded", "channel-license bad", and "time gap" could be ignored. A pattern such as a particular instrument continually exceeding its range was to be reported to the project subtask leader, or DAS personnel as it might have been recoverable, the instrument may have needed repair, or the BREAD limits may have needed to be changed. All flagged lines were to be checked in both the MSGS list and in the data file itself, and the flags removed if the line were correct.
- 4) Fiche copies of the STAT and MSGS files were to be filed in project Q/A files. (Fiche copies are not available for data files SF002 through SF053. The RJET working copies are being kept instead.)
- 5) A Q/A record sheet was made by xeroxing the last page of the working copy (NIPS or RJET) of the MSGS file. Included were a number of error message lines, the error synopsis, and the first and last times in the input and output files. The interface file name used with the run, and the output S-file name were written on the sheet. Instructions were added for file modifications and/or further BREAD runs, or to store the file as it was. Finally, the sheet was initialed and dated, and a copy entered in the project Q/A files. Another copy was given to the person who was to implement the instructions.

Table 2.2-2 is the record of all BREAD processing. The sequence number is the last one assigned by BREAD to each file (the number was also incremented during other operations to be discussed in the next section). The "discard" column gives the number of records either preemptively discarded as discussed above or discarded for cause (Note that file SF000A/B shows no discards. This file consists entirely of VWSM data, entered as described in Section 5.2.2.). The "NUMBER OF ERRORS" columns enumerate those data which were lost because they were unreadable or obviously wrong and uncorrectable. These represent about 2% of the acquired data. The "copied" column includes both those records judged as valid and those flagged as questionable. A total of 8,691,636 data points were copied by BREAD during the 1300-day (3.56-year) period of the test, for an average of 6682 data points per day.

2.3 Data Fixes (SFIX)

Records flagged by BREAD as questionable required further examination and were either deleted or modified before the file was fed back into BREAD or accepted for further processing. All modifications were done on S-files because the files are ASCII at that stage. When possible, a general purpose editor was used, but some problems required writing special codes.

Most modifications and deletions were done with TRIX, a line-oriented editor on LTSS. If bad, the lines were deleted. If good, only the flags were deleted. Some examples of problems solved by using TRIX follow.

The first nineteen S-files consistently produced six "new license numeric" errors. The problem was that two groups of channels, 414, 415, and 416, on Node 100, and 1382, 1383, and 1385, on Node 200, were given the same set of licenses, CCE001, CCE002, and CCE004. Later they were changed to CCE10* on Node 100, and CCE20* on Node 200. (NOTE: in this notation the * is a "wild card" and takes on successively the values 1, 2, and 4.) Since the channel and license are adjacent, the problem was handled with a TRIX pattern replacement for each of the six channels, on each of the 19 files. Each file was then re-sorted and fed back through BREAD for confirmation.

Several problems required special purpose, small codes to be written, the first was called SFIX. SFIX cured two problems:

- 1) Early on, Node 100 thermocouples (TC's) were recorded in microvolts instead of volts, the units the algorithm expects. The problem appears to have been corrected on or about JD44350. This date falls towards the end of tape SFT005, and within an extended data gap. The begin and end times for the gap vary from instrument to instrument, but the date chosen separates "volt data" from "microvolt data" in all cases.
- 2) From the beginning of the test to JD44451 (about 140 days), the wiring for TC's SGT011 and SGT044 were interchanged.

SFIX reads an S-file, passing all Node 200 and non-TC data through without change. Otherwise, all occurrences of LCN=278, license=SGT044 are replaced with LCN=275, license=SGT011, and vice versa. Then all raw values for TC's before JD44350 are multiplied by 1.E-06. Finally the file is re-sorted by license and time, since the above changes perturbed that order. The output file has the same name as the input file with the version character incremented by one. Table 2.3-1 shows the number of lines affected in each file processed.

Over the July 4, 1982 weekend, a failure of the system clock caused incorrect times on one day's data. SFIX2 corrected this by subtracting 150.4 from times in the range JD45305.851 to JD45306.776, on file SF055A/A and resorting the file. The new file, SF055A/B, was run through BREAD on November 4, 1982 to make SF055A/C, which was stored. A total of 5562 records were corrected. The fact that there was no overlap between the good and bad time values on this file made the job easier.

The system clock was initially set to local time, and wasn't reset to Greenwich Standard Time (GMT) until JD44373 (May 13, 1980). Pacific Standard Time (PST) is 8 hours later than GMT. SFIX3 corrected this by adding 0.33333 to all Julian time values less than 44373.00000, and re-sorting the data. The file version was incremented by one, and the files were not resubmitted to BREAD. This was done by M. L. Higuera, on 5/6/83, and involved files SF002A/F through SF011A/E as output by SFIX (see Table 2.3-1).

Table 2.2-1. Usage of BREAD and SFTINT versions.

<u>BREAD VERSION</u>	<u>SFTINT VERSION</u>	<u>S-FILES</u>
9	SPEC1	SF002A/E-SF005A/C
9	6	SF022B/A
9	7	SF006A/C-SF017B/C
9	8	SF019A/C-SF021A/B
9	9	SF018A/F, SF023A/B-SF032A/C
9	10	SF000A/B, SF022A/B, SF033A/C-SF039A/B
9	11	SF039B/B-SF042B/A
9A	14	SF043A/E-SF045B/A
10A	14	SF046A/D-SF053A/B
10A	15	SF054A/A, SF056A/A, SF057A/A
11A	16	SF055A/C, SF055B/C, SF058A/A-SF063A/A
11A	17	SF064A/A-SF067B/A
11A	18	SF069A/B, SF069B/B
11A	18A	SF068A/B, SF070A/B, SF070B/B
12	18A	SF073B/A, SF075A/A
12	18B	SF071A/B, SF071B/B
12	19	SF072A/D, SF072B/B
12	19A	SF073A/B, SF074A/B

Table 2.2-2. Summary of BREAD processing.

File Name	Time, Absolute Julian Day		Number of data points			Number of errors			
	Start	Stop	Copied	Discard	Total	Range		License	License and Channel
						TOR ^a	VOR ^b		
000A/B	44331.437	44569.498	30191	0	30191	--	--	--	--
002A/E	44342.196	44354.011	25393	11407	36800	0	144	39	0
003A/C	344.790	345.250	1692	2245	3937	0	0	0	143
004A/C	345.389	346.967	11181	6548	17729	32	90	32	149
005A/C	346.960	351.929	26491	13114	39605	18	21	0	0
006A/C	351.914	351.917	37567	7027	44594	0	81	0	0
007A/D	357.845	358.507	7145	1636	8781	0	4	0	0
008A/D	358.485	360.566	8883	2427	17310	0	231	0	0
009A/D	359.926	361.134	17281	5971	23252	0	1451	0	0
010A/C	361.143	370.452	119807	45263	175070	0	54	0	0
011A/D	370.452	375.167	50161	18770	68931	0	44	0	0
012A/C	375.161	388.456	150312	57590	207902	0	141	0	0
013A/C	388.196	409.271	159424	58090	217514	0	300	33	0
014A/D	409.266	416.590	91569	28941	120510	0	73	196	0
015A/C	416.590	421.242	45953	14735	60688	0	28	67	0
016A/C	421.246	438.653	182950	68700	251650	0	108	409	0
016B/C	438.648	451.121	158409	52772	191181	0	79	320	0
017A/C	451.107	467.378	178992	68629	247621	0	50	0	0
017B/C	467.161	474.286	72545	23302	95847	3	10	0	0
018A/F	474.278	490.198	154345	56843	211188	6	35	220	205

Table 2.2-2. Continued.

File Name	Time, Absolute Julian Day		Number of data points			Number of errors			
	Start	Stop	Copied	Discard	Total	Range		License	License and Channel
						TOR ^a	VOR ^b		
019A/C	490.193	501.576	118107	40305	158412	0	58	24	0
020A/B	501.563	513.328	97757	48058	145815	0	7	21	0
021A/B	513.321	526.480	156160	69170	225330	0	2	0	0
022A/B	526.478	541.537	172533	64458	236991	0	5	0	1
022B/A	541.532	550.332	115831	73133	188964	0	4	0	0
023A/B	550.252	562.241	113601	50159	163760	0	24	161	0
024A/B	557.484	576.247	72353	31718	102071	0	38	2	0
025A/C	529.807	590.272	104444	31095	135539	0	60	39	0
026A/C	577.327	610.263	84131	117970	202101	0	13	8	0
027A/C	610.564	618.247	40686	203970	244650	12	8	84	229
028A/C	618.247	632.397	84205	165522	249727	2	16	204	0
029A/C	632.368	651.453	88284	164419	252703	0	11	12	0
029B/C	650.669	661.224	30935	53536	84471	0	266	3	0
030A/C	656.339	686.187	90861	157447	248308	1	7	3	47
030B/B	686.067	695.245	45207	95148	140355	0	4	3	0
031A/C	695.350	705.889	48884	43058	91942	14	186	19	606
032A/C	703.304	722.290	78070	80297	158367	3	8	102	23
033A/C	722.617	781.117	124320	123839	248159	1	37	1	160
034A/B	723.271	772.087	141038	108318	249356	0	79	11	0
034B/B	772.087	781.122	22451	20664	43115	0	2	1	0

Table 2.2-2. Continued.

File Name	Time, Absolute Julian Day		Number of data points			Number of errors			
	Start	Stop	Copied	Discard	Total	Range		License	License and Channel
						TOR ^a	VOR ^b		
035A/C	781.126	801.610	72433	56439	128872	0	22	1	245
036A/C	781.122	802.173	45460	54589	100049	0	286	3	678
037A/B	802.184	826.246	125763	122361	248124	0	6	3	0
037B/B	826.180	842.202	60618	60467	121085	0	5	184	0
038A/C	837.205	852.215	59890	51625	111515	1	2	1	0
039A/B	852.223	873.582	106996	129470	236466	0	12	206	0
039B/B	873.582	890.343	139520	72851	212371	1	28	28	0
040A/A	890.566	905.159	65577	89464	155041	0	10	20	0
041A/A	905.151	932.186	137485	114641	252126	0	31	6	0
041B/B	932.184	939.266	30576	27134	57710	0	2	1	0
042A/B	939.300	965.522	119826	124187	244013	2	102	80	0
042B/A	965.484	984.225	78904	82118	161022	0	5	75	0
043A/E	990.234	5005.301	101456	119178	220634	1	117	1869	12
044A/B	45005.305	5053.225	132236	114582	246818	2	6	109	166
045A/A	45005.260	45030.390	87612	48097	135709	0	44	333	0
045B/A	45030.397	45053.204	81367	47567	128934	0	72	0	0
046A/D	45053.229	45077.681	186845	59844	246689	1	111	59	46
046B/B	45077.681	45080.213	137590	112400	149990	0	14	0	0
047A/D	45053.207	45080.231	116475	79060	195535	1	562	3	46
048A/A	45080.271	45084.987	115728	12690	28418	0	13	319	0

Table 2.2-2. Continued.

File Name	Time, Absolute Julian Day		Number of data points			Number of errors			
	Start	Stop	Copied	Discard	Total	Range		License	License and Channel
049A/B	45080.683	45106.363	84845	166315	251160	1	154	16	493
049B/A	45106.361	45109.549	21836	16270	38106	0	15	1	0
050A/B	45085.646	45103.386	44184	34166	78350	1	49	16	217
051A/A	45110.252	45133.155	187505	67807	255311	0	260	66	0
051B/B	45133.153	45152.179	149434	58448	207882	0	82	104	0
052A/A	--	--	0	125108	125108	8738	20	8775	112568
053A/B	45129.603	45148.636	177163	55377	232540	1	51	1	46
054A/A	45152.319	45177.430	28130	23752	51882	0	2	0	0
055A/C	45152.182	45169.359	161569	91101	252670	433	24	576	5035
055B/C	45169.354	45177.468	38772	93132	131904	1731	22	1769	65921
056A/A	45177.431	45201.199	77471	68863	146334	0	65	773	0
057A/A	45177.411	45201.192	70506	61908	132414	0	97	168	0
058A/A	45201.192	45221.369	36943	62424	119367	0	39	162	0
059A/A	45201.199	45218.443	50135	204568	254703	0	5	189	0
060A/A	45226.448	45256.339	76218	88038	164256	0	4	21	0
061A/A	45221.416	45256.336	99734	92536	192270	0	49	0	0
062A/A	45256.339	45288.544	141186	106148	247334	1	12	245	46
062B/A	45288.533	45292.298	19574	199242	39498	0	5	167	0
063A/A	45256.339	45285.208	62320	55826	118146	0	30	109	0
064A/A	45292.298	45331.300	115960	145014	240774	1	1191	29	46

Table 2.2-2. Continued.

File Name	Time, Absolute Julian Day		Number of data points			Range		Number of errors	
	Start	Stop	Copied	Discard	Total	TOR ^a	VOR ^b	License	License and Channel
065A/A	45292.219	45339.403	127878	127829	255707	1	83	7	46
065B/A	45339.406	45340.228	1297	481	1784	0	0	0	0
066A/A	45341.326	45359.430	27484	27326	54810	0	0	22	0
067A/A	45340.229	45379.239	141259	109019	250278	0	4299	1	0
067B/A	45379.239	45396.197	52839	41121	93960	0	17	0	0
068A/B	45359.430	45396.235	97187	103609	200796	1	14	319	46
069A/B	45397.554	45436.390	126985	127955	254940	45	7	413	88
069B/B	45436.390	45453.232	42422	20740	63162	0	0	0	0
070A/B	45396.197	45429.555	137282	112707	249989	0	89	140	0
070B/B	45429.558	45453.226	74244	28242	102486	0	40	258	0
071A/B	45453.235	45521.314	167626	86240	253866	0	119	0	0
071B/B	45521.312	45533.418	198636	24606	223242	0	819	0	0
072A/D	45453.229	45527.182	178901	75150	254051	349	304	327	14331
072B/B	45527.184	45544.350	33302	10198	43500	0	428	66	0
073A/B	45533.418	45596.208	169408	84416	253824	0	591	112	0
073B/B	45596.208	45632.198	36513	44286	80799	0	524	168	0
074A/B	45544.350	45613.077	165178	55213	220391	1	746	2660	54
075A/A	45613.080	45632.194	7404	14671	22075	0	0	0	0

Table 2.2-2. Continued.

File Name	Time, Absolute Julian Day		Number of data points			Number of errors			
	Start	Stop	Copied	Discard	Total	Range		License and Channel	
						TOR ^a	VOR ^b	License	Channel
Totals									
00-45	44331.437	45053.225	4785868	3601064	8386932	99	4599	4933	2663
46-65	45053.229	45340.228	2249098	2009035	4258133	10910	3056	14075	184510
66-75	45341.326	45632.194	1656670	965499	2622169	395	7997	4486	14519
overall	44331.437	45632.194	8691636	6575598	15267234	11404	15652	25494	201692

^aTOR, Time out of range^bVOR, value out of range

Table 2.3-1. Changes by SFIX and SFIX3.

Input File	Microvolts to Volts	Number of changes			SFIX Output File	SFIX3 Output File
		SGT011 to SGT044	SGT044 to SGT011	Lines Processed		
SF002A/E	9,110	25	24	25,393	SF002A/F	SF002A/G
SF003A/C	254	1	1	1,692	SF003A/D	SF003A/E
SF004A/C	6,855	17	16	11,181	SF004A/D	SF004A/E
SF005A/C	3,004	6	6	26,491	SF005A/D	SF005A/E
SF006A/C	0	18	20	37,567	SF006A/D	SF006A/E
SF007A/D	0	5	5	7,415	SF007A/E	SF007A/F
SF008A/D	0	5	5	8,883	SF008A/E	SF008A/F
SF009A/D	0	10	10	17,281	SF009A/E	SF009A/F
SF010A/C	0	61	60	119,807	SF010A/D	SF010A/E
SF011A/D	0	27	27	50,161	SF011A/E	SF011A/F
SF012A/C	0	78	78	150,312	SF012A/D	
SF013A/C	0	87	87	159,424	SF013A/D	
SF014A/D	0	52	52	91,569	SF014A/E	
SF015A/C	0	15	15	45,953	SF015A/D	
SF016A/C	0	99	99	182,950	SF016A/D	
SF016B/C	0	92	92	138,409	SF016B/D	
TOTAL	19,223	598	598	1,074,488		

3.0 CONVERSION TO BINARY (MFAB,SCAN)

Since the data is acquired under the control of two computers, and the computers buffer their data to tape independently, the tapes are not time sequential. That means two tapes, or even two sections of one tape may have data which overlap in time. In fact, it was fairly normal to get one tape with predominantly Node 100 data, and another with Node 200 data, the tapes having nearly 100% time overlap. MFAB (Merge Files, Ascii to Binary) merges the overlapped data and converts the data to binary form in one step.

MFAB reads up to 3 ASCII S-files, and makes a binary output file with five 60-bit CDC-7600 words per input record. The first word contains the LCN and license, packed in 14,A6 format. The other four words contain floating point values of time, HP converted value, raw data value, and REVERT converted and corrected value. In addition, MFAB allows one of its own output files as an input file, to cover those situations where data from more than three S-files is required in one binary, or B-file. MFAB selects, in proper order by license and time, all the data from the ASCII and binary files that fall between two input Julian times. For simplicity, the times are selected as whole-day values which produce an output file of nearly one million words. The only documentation available for MFAB is a memo of limited distribution (Hage to Dist., SFT 82-96, June 3, 1982). For the record, then, an example dialog is reproduced here (user responses underlined):

- 1) MFAB2 / T Y
- 2) TYPE ASCII FILENAMES SF021A/B SF025A/C SF022A/B
- 3) TYPE BINARY INPUT FILENAME BT03

 TYPE FIRST, LAST TIMES (JULIAN)
- 4) 44516.,44532.,

 NUMBER OF DATA LINES COPIED

SF021A/B 122294

SF025A/C 1183

SF022A/B 69775

BT03 3420

B44532 196672

ALL DONE

MFAB2 is a second version of MFAB which automatically sorts the input ASCII files if it finds them unsorted. The file BT03 is a "temporary" (really intermediate) binary file made in an earlier run of MFAB2. A final file was named with its ending time. For example, the file made by answering the beginning and ending times line with "44780.,44815.", would be named B44815. Both the "temporary" and final binary files are stored in directory .SFT:B-FILES. All input files must be on disk when MFAB2 is started. The ASCII files are stored in directory .SFT:S-FILES.

File BT03 is special in that it contains early VWSM data (from file SF000A/B) over a 240-day time span (see Section 5.2.2). By examining Table 3-1 one can see how this data was spread over the first twelve B-files. The first B-file, B44365, required data from ten S-files, so three intermediate files were used, BT03, BT06, and BT09. The first three S-files were merged into BT03, then BT03 and the second three S-files were merged into BT06, BT06 and the third three S-files became BT09, and finally, BT09 and SF010A/E became B44365. BT03 was then used directly as binary input for the next eleven B-files, B44382 through B44572.

The running of MFAB2 is the easy part, the hard part was choosing which files should be used as input, and what time range should be used. By examining the "number of data points copied" column of Table 2.2-1, one can get an idea of which files will be merged in entirety, and which have to be broken to obtain output files of 200,000 lines (one million words). During

periods when overlap problems were severe, it was necessary to make a sorted list of all the beginning and ending times for the input S-files on a worksheet, then add the file names in adjacent columns of the worksheet as shown in Fig. 3-1. As shown, on JD45453 four files began or ended in a one-hour interval.

To find out exactly where to break the files, a special code was written, called SCAN. SCAN would read an S-file, and tabulate, on integer Julian days, the number of records per day, and the accumulated number of records since the beginning of the file. The files with this data were given the same name as the S-file, with the S replaced by an X, and the files were stored in directory .SFT:X-FILES. By laying the X-file listings for the appropriate S-files side-by-side, and using a calculator to sum the records which resulted from tentative choices of ending days, a final choice could be made. (NOTE: The beginning day for a final binary file was fixed by the ending day of the one preceding.) Although there were only two tape decks on the DAS, we frequently find three S-files overlapping in Fig. 3-1. This is because the data was written to tape separately by the two computer nodes, and the data at the end of one buffer could be from a later time than the beginning data of the following buffer. Since the tapes were not monotonic in time, the two or three files from one tape can overlap slightly. Most of the time, the selection of where to build "temporary" B-files was straightforward, although on one occasion an additional worksheet was used to reduce the number of B-files needed.

Once the breakdown of files and times was chosen, an instruction sheet was prepared for the operation. The merge was done in five groups, June 1982, March 1983, May 1983, February 1984, and May 1985. Two of these were to correct errors. The May 1983 group was a remerge of those files modified by SFIX3. The May 1985 merge was to correct an overlap between files B44815 and B44857. The record of all merges is shown in Table 3-1, in the same format as the instruction sheet used to guide the work. For each file used for input or output, the number of records expected to be transferred is given. This was compared with the "number of lines copied" as printed to the terminal by MFAB, to be sure the merge was done properly.

Table 3-1. Record of S-file merges.

<u>Time Range</u>		<u>ASCII Input</u>		<u>Binary Input</u>		<u>Binary Output</u>		<u>OP. Date</u>
<u>Start</u>	<u>Stop</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	
44330	44572	SF000A/B	30191	---	---	BT03	57276	MLH5/06/83
		SF002A/G	25393					MLH5/06/83
		SF003A/E	1692					"
44330	44365	SF004A/E	11181	BT03	29080	BT06	104312	"
		SF005A/E	26491					"
		SF006A/E	37567					"
44330	44365	SF007A/F	7415	BT06	104319	BT09	137898	"
		SF008A/F	8883					"
		SF009A/F	17281					"
44330	44365	SF010A/E	49214	BT09	137898	B44365	187112	"
44365	44382	SF010A/E	70593	BT03	1843	B44382	197830	"
		SF011A/F	50161					"
		SF012A/D	75233					"
44382	44406	SF012A/D	75079	BT03	3002	B44406	195011	MLH6/11/82
		SF013A/D	119932					"
44406	44421	SF013A/D	39493	BT03	2090	B44421	177258	"
		SF014A/E	91569					"
		SF015A/D	44106					"
44421	44440	SF015A/D	1847	BT03	2071	B44440	202354	"
		SF016A/D	182950					"
		SF016B/D	15486					"
44440	44458	SF016B/D	122924	BT03	2109	B44458	199828	"
		SF017A/C	74795					"
44458	44478	SF017A/C	104197	BT03	969	B44478	196880	"
		SF017B/C	72545					"
		SF018A/F	19169					"
44478	44496	SF018A/F	135177	BT03	3344	B44496	199062	"
		SF019A/C	60541					"
44496	44516	SF019A/C	57567	BT03	4617	B44516	193807	MLH6/11/82
		SF020A/E	97757					"
		SF021A/B	33866					"
44516	44532	SF021A/B	122294	BT03	3420	B44532	196672	NF6/15/82
		SF025A/C	1183					"
		SF022A/B	68775					"
44532	44549	SF022A/B	102758	BT03	2907	B44549	204327	"
		SF022B/A	98662					"

Table 3-1. Continued.

<u>Time Range</u>		<u>ASCII Input</u>		<u>Binary Input</u>		<u>Binary Output</u>		<u>OP. Date</u>
<u>Start</u>	<u>Stop</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	
444549	44572	SF022B/A	17169	BT03	1824	B44572	192608	NF6/17/83
		SF023A/B	113601					"
		SF024A/B	60014					"
44572	44610	SF024A/B	12339			B44610	198913	NF6/15/83
		SF023A/C	103261					"
		SF026A/C	83313					"
44610	44648	SF026A/C	818			BT28	125709	"
		SF027A/C	40686					"
		SF028A/C	84205					"
44630	44648	SF029A/C	72261	BT28	125709	B44648	197970	"
44648	44699	SF029A/C	16023			BT30	137819	"
		SF029B/C	30935					"
		SF030A/C	90861					"
44648	44699	SF030B/B	45207	BT30	137819	B44699	198635	"
		SF031A/C	15609					"
44699	44742	SF031A/C	33275			BT32	111345	"
		SF032A/C	78070					"
44699	44742	SF033A/C	41052	BT32	111345	B44742	199091	"
		SF034A/B	46694					"
44742	44780	SF033A/C	80648			B44780	194348	NF6/15/83
		SF034A/B	94344					"
		SF034B/B	19356					"
44780	44815	SF033A/C	2620			BT35	78148	NF6/17/82
		SF034B/B	3095					"
		SF035A/C	72433					"
44780	44815	SF036A/C	45460	BT35	78148	B44815	190611	"
		SF037A/B	67003					"
44815	44857	SF037A/B	96516			BT38	217024	RCS/2/85
		SF037B/B	60618					"
		SF038A/C	59890					"
44808	44857	SF039A/B	17242	BT38	217024	B44857	234266	NF6/17/82
44857	44885	SF039A/B	89754			B44885	197497	"
		SF039B/B	107743					"
44885	44925	SF039B/B	31777			B44925	199044	"
		SF040A/A	65577					"
		SF041A/B	101690					"

Table 3-1. Continued.

<u>Time Range</u>		<u>ASCII Input</u>		<u>Binary Input</u>		<u>Binary Output</u>		<u>OP. Date</u>
<u>Start</u>	<u>Stop</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	
44925	44965	SF041A/B	35795			B44965	183585	NF6/17/82
		SF041B/B	30576					"
		SF042A/C	117214					"
44965	45005	SF042A/C	2612			B45005	181029	NF6/17/82
		SF042B/A	78904					"
		SF043A/E	99513					"
45005	45054	SF043A/E	1946			BT39	170925	MLH3/02/83
		SF045A/A	87612					"
		SF045B/A	81367					"
45005	45036	SF044A/B	85689	BT39	109857	B45036	195546	"
45036	45065	SF044A/B	46548	BT39	61068	B45065		"
		SF046A/D	30137					"
		SF047A/D	57930					"
45065	45077	SF046A/D	119608			B45077	165964	"
		SF047A/D	46356					"
45077	45081	SF046B/B	137591			BT40	186882	"
		SF046A/D	37101					"
		SF047A/D	12190					"
45077	45082	SF048A/A	5726	BT40	186882	B45082	196036	"
		SF049A/B	3428					"
45082	45107	SF048A/A	10003			BT41	135605	MLH3/07/83
		SF049A/B	81418					"
		SF050A/B	44184					"
45082	45117	SF049B/A	21837	BT41	135605	B45117	193223	"
		SF051A/A	35781					"
45117	45136	SF051A/A	151725			B45136	193203	"
		SF051B/B	14056					"
		SF053A/B	27422					"
45136	45148	SF051B/B	70974			B45148	186107	"
		SF053A/B	115133					"
45148	45170	SF051B/B	64405			BT42	260584	"
		SF053A/B	34609					"
		SF055A/C	161570					"
45148	45162	SF054A/A	3771	BT42	187752	B45162	191523	"

Table 3-1. Continued.

<u>Time Range</u>		<u>ASCII Input</u>		<u>Binary Input</u>		<u>Binary Output</u>		<u>OP. Date</u>
<u>Start</u>	<u>Stop</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	<u>File</u>	<u># Lines</u>	
45162	45202	SF054A/A	24360	BT42	72832	BT43	206472	MLH3/07/83
		SF055B/C	38773					"
		SF057A/A	70507					"
45162	45188	SF056A/A	30197	BT43	166788	B45188	196985	"
45188	45221	SF056A/A	47275	BT43	39684	B45221	193047	"
		SF058A/A	55952					"
		SF059A/A	50136					"
45221	45289	SF058A/A	992			BT44	241914	"
		SF061A/A	99735					"
		SF062A/A	141187					"
45221	45261	SF060A/A	76219	BT44	109686	B45261	194884	"
		SF063A/A	8979					"
45261	45291	SF062B/A	12972	BT44	132228	B45291	198542	"
		SF063A/A	53342					"
45291	45329	SF062B/A	6603			B45329	195102	"
		SF064A/A	109452					"
		SF065A/A	79047					"
45329	45380	SF064A/A	6308			BT45	196398	LLR2/9/84
		SF065A/A	48831					"
		SF067A/A	141259					"
45329	45364	SF065B/A	1279	BT45	155406	B45364	195031	"
		SF066A/A	27485					"
		SF068A/B	10843					"
45364	45397	SF068A/B	86345	BT45	40992	B45397	183894	LLR2/16/84
		SF067B/A	52840					"
		SF070A/B	3718					"
45397	45423	SF070A/B	109724			B45423	198983	"
		SF069A/B	89259					"
45423	45454	SF069A/B	37727			BT46	154392	"
		SF070B/B	74245					"
		SF069B/B	42423					"
45423	45458	SF072A/D	14482	BT46	154395	B45458	204494	"
		SF071A/B	11780					"
		SF070A/B	23841					"
45458	45498	SF072A/D	107405			B45498	199372	LLR2/9/84
		SF071A/B	91967					"

Table 3-1. Continued.

<u>Time Range</u>		<u>ASCII Input</u>		<u>Binary Input</u>		<u>Binary Output</u>		<u>OP, Date</u>
Start	Stop	File	# Lines	File	# Lines	File	# Lines	
45498	45545	SF072A/D	57015			BT47	154198	LLR2/9/84
		SF071A/B	63880					"
		SF072B/B	33303					"
45498	45531	SF071B/B	58728	BT47	128073	B45531	186801	"
		SF073A/B	38791					"
45542	45583	SF073A/B	102154	BT47	6449	B45583	195705	"
		SF074A/B	87102					"
45583	45633	SF073A/B	28463			BT48	143052	"
		SF074A/B	78075					"
		SF073B/A	36514					"
45583	45633	SF075A/A	7405	BT48	143052	B45633	150457	"

Figure 3-1. An example worksheet for planning the MFAB merging process.

45205.260	45A/A				340.229	64A/A	67A/A	
45236.320	↓				341.326	↓	↓	68A/B
45236.327	45B/A				357.436	67B/A	↓	
45253.204	↓				359.259	↓	70A/B	
53.207	47A/D				362.197	↓	↓	
53.238	↓	46A/D			366.255	64A/B	↓	
71.681	↓	↓			377.354	↓	725/B	
80.231	↓				429.335	↓	↓	
80.271	48A/A				429.558	↓	69A/B	
80.683	↓	49A/B			436.590	↓	↓	
89.987	↓	↓			453.226	↓	72A/D	
85.646	50A/B				453.229	↓	↓	
103.786	↓				453.232	↓	71A/B	
106.361	49B/A				453.255	↓	↓	
106.363	↓				501.312	71B/B	↓	
109.549	↓				524.344	↓	72B/B	
110.252	51A/A				527.182	↓	73A/B	
129.603	↓	53A/B			527.184	↓	↓	
133.153	↓	↓	51B/B		539.416	74A/B	↓	
137.153	↓	↓	↓		546.350	↓	73B/A	
144.656			↓		576.208	↓	↓	
152.179			55A/C		613.077	75A/A	↓	
152.182			↓		615.080	↓	↓	
152.318		54A/A	↓		632.194	↓	↓	
169.354	55B/C	↓	↓		632.198	↓	↓	
169.359	↓	↓	↓					
177.407	57A/A							
177.413	↓		56A/A					
177.430	↓		↓					
201.198	58A/A		↓					
201.199	↓		↓					
218.443	59B/A		↓					
231.367	↓		61A/A					
231.416	↓		↓					
246.888	60A/A		↓					
256.326	↓		62A/A					
256.339	↓		↓	63A/A				
285.208			↓	↓				
286.533			65A/A	62B/A				
288.544			↓	↓				
292.219			65A/A	↓				
292.288	64A/A		↓	↓				
331.301	↓		↓	↓				
339.403			65B/A	↓				
339.406			↓	↓				
340.238			↓	↓				

4.0 REVERT GENERAL ARCHITECTURE

REVERT is described most completely in the user's guide (Hage,1984), but discussions of various improvements made year to year appear in the sequence of Interim Reports (Carlson et al., 1980; Patrick et al., 1982; Patrick et al., 1983; and Patrick et al., 1984a). Fundamentally, REVERT duplicates the NTS process of converting raw data to engineering units, but adds temperature correction algorithms. As mentioned in Section 1.3, the NTS system made use of a Descriptive Database, so a routine to translate that database to a form efficient for use on the 7600's is included, along with a routine to list the new database. Also, since any one copy of the NTS database contained only those licenses present at the time the copy was made, REVERT includes a routine to merge a new NTS database from tape into an existing 7600-compatible database, to obtain a database with all the licenses on either. Finally, a database management function, ALTER, is provided by REVERT to allow entry and modification of parameters needed in the temperature conversion process, or to document the change with time of the instruments and/or their algorithms. The interconnection of these functions is shown in Fig. 4-1. Here the tape copy of the NTS database is called a "dump." Appendix A is a fiche of source listings of all codes used in the R-files part of the Livermore system. Most are well commented and include the history of changes made at each version number.

4.1 Listing a Database (LIST)

As shown in Fig. 4-1, LIST is called from several places in REVERT. This is because LIST knows the format needed to display the descriptive data of each of the various instrument types, and that same format is needed whichever routine is requesting the listing. LIST may be called each time a coefficient block is read from an HPDB file preparatory to a processing run. Either a full, double spaced listing of the block (up to 12 lines) is produced, or a single line containing only the references to other licenses is made. A full listing is made whenever a coefficient block has been altered. If the new data are being read from an NTS dump, LCN's are given instead of licenses, since the license won't be known until a table of license versus LCN for that dump can be made. Three tables are produced: 1) a multicolumned table of

LCN's, licenses, and index numbers, sorted by LCN, 2) the same items sorted by license, and 3) a cross index of all referenced licenses, giving a list of all licenses which reference them.

4.2 Creating a Database

The translation of a dump tape into a 7600-compatible database file is complicated by the difference in word size between the HP and 7600, the "general purpose database" format of the dump file, and the fact that the dump contains data not needed by the Livermore system, and is missing other data which is needed. The dump contains five files. Files two and four contain the alarm message records and the scan tables respectively and are not needed in Livermore. File one contains the date the tape was written. File three is a database map file which contains the names of the parameters present in the same order as their location in file five. Each record in file five contains the number of items in the record, the item numbers, the field size of each item, and finally, the contiguously packed items themselves.

To retrieve an item requires scanning the item name list to see if it is present and obtain its item number, scanning the item number list to find which field it is in, and summing the field width list to determine the location of the field in the packed data string. This method saves space, and allows the size and content of the records to change with time, but is very slow. The Livermore system assigns a 100-word block to each license, even though that license may be a pass one device needing only 12 words. Its advantage is that each word has a known, fixed, address and can be retrieved immediately, without searching.

The 7600-compatible database files were called HBDB-files. The actual name of an HPDB-file created from a dump tape was HPDBYYMMDD, where yymmdd was the date written in the first file of the dump tape. There were 22 dump tapes, and all were copied to disk before translation (Table 4.2-1). The disk files were named HPTPYMMDD, where the YYMMDD was the date written on the tape reel label (not necessarily the same as the date written on the first file.) The HPDB-files and the HPTP-files were saved in directories .SFT:HPDB and .SFT:HPTP, respectively.

In order to accomplish the translation from HPTP to 7600 form, REVERT reads a file which gives the itemnames to be retrieved from the dump, and the location within the 100-word block in the HPDB-file to store the item. An example of the ITEMNAME file is given as Fig. 4.2-1. Characters to the right of the fourth itemname-location pair are ignored by REVERT and used for comment. The numbers to the right indicate which version numbers involved changes to that line. Both the number of items and their names changed with time. The itemnames flagged with negative locations are references to other instruments. In the dump tape, these are given in terms of LCN. In the Livermore system, these references must be made by license, since the LCN's for some licenses change with time. REVERT thus made two passes in translating the dump tapes to HPDBByymmdd files. On pass one, all needed data was copied to the HPDB-file as it appeared in the dump tape, accumulating, as it went, a table of license versus LCN for that particular dump tape. On the second pass, the LCN's were converted to licenses using the table. Note that this table is not the same as the LCN versus license table used with BREAD, since the dump was not always taken at the time the change was entered into the HP data base system. Because of this, and other reasons to be discussed below, HPDB-files translated from HPTP-files were not used directly, but required merging and extensive modification.

4.3 Merging Databases

The early HPTP-files had a great deal of missing or erroneous data. To avoid loading all this misinformation into the HPDB-files, we decided to build a "base" HPDB-file by merging data from the first 21 HPTP-files in reverse order. New data was loaded to the "base" file only if the license in question did not already exist there. This process loaded the latest, and presumably most complete and correct data for each license. The "base" file was named HPDM4/83M, and was the file on which all ALTER runs were made.

4.4 Modifying a Database

The ALTER routine in REVERT contains a number of powerful editing functions, controlled by an ASCII file named successively RC4 through RC15E (Hage, 1984, pp 13-18). As noted in Fig. 4-1, REVERT does not allow data

processing in the same run as an ALTER. This is to prevent data conversion by data bases with undocumented ALTERs. Each time an ALTER run is made, a listing is produced showing each change in the order it occurred. In this way, one can watch for interactions between successive changes. In the event a change is made to many instruments, via the CD, CM, or CO options (Hage, 1984, pp 13-18), the change was shown explicitly only for the first license changed, and the other licenses were simply listed. After the ALTER run, REVERT is usually rerun in the list mode to produce a listing of the final form of the new database. Appendix B is a fiche listing of the final database, HBDB15E, and Appendix C is a fiche listing of the ALTER file which produced it, RC15E. The data base listing includes index lists, ordered by channel and license, and a cross index of referenced instruments along with the instruments which reference them (also described in Section 4.1). A history of changes is included at the beginning of the ALTER file.

4.5 Processing (PROCS)

Temperature correction of the SFT-C instruments must be done in three passes. Those instruments which can be converted with no reference to another instrument are processed first, and called "pass 1" instruments. These include the watt meters, the RTD'S (resistance temperature devices), excitation supplies, and several others. Those which can only be converted by reference to at least one pass 1 device are called "pass 2" devices, and are processed second. This group consists entirely of the thermocouples (TC's), all of which reference an RTD to measure their cold junction temperatures. Those devices which can only be converted by reference to at least one pass 2 device are called "pass 3" devices and are processed last. This group includes all devices needing temperature correction, since the primary temperature measurement device is the TC, a pass 2 device.

It is the PROCS routine that schedules the order of conversions, and selects the proper FIT routine to do the conversion and correction. These routines are all named FITxx, where the xx is the device type, a two character indicator stored in the database. Pass 1 is processed in the order the data appears in the B-file, i.e., sorted by license and time, and a table is accumulated of the address in the input disk file of the first and last valid

records for each license. Valid records for a given license are those for which a coefficient block exists, i.e., the time word of the record falls within the valid time frame of a coefficient block with the proper license. Passes 2 and 3 are then processed in the order listed in the table, and no further data reads are necessary for validation purposes.

Each FIT routine receives the license, time, and raw value, and, if the device is a pass 2 or 3 device, checks the coefficient block appropriate for that license and time frame to see what reference licenses are needed. The FIT routine then calls routines which search the input data file for the reference data bracketing the needed time (GCBFR), and interpolate the data to that time (RVAL). The converted and corrected data are then written into the space allotted for them in the input file (see MFAB, chapter 3). Note that the existence of the valid reference data is verified by a check of the license/record address table accumulated during pass 1 and, if missing, the "unable to convert" flag (a converted data value of -9999.) is written with no further reference to the data.

When all three passes are finished, REVERT appends an R to the B-file name, and lists out a table of licenses processed, with their LCN's, the number of records found for each license, and the number of times each license was referenced by another license. The new file, now called an R-file, is stored in .SFT:R-FILES.

In order to minimize errors and reduce user interaction time, the whole process was controlled by a BCON control file. BCON is a control file driven process controller available on LTSS. This file, RVCONTROL, contains all terminal dialog normally required to retrieve the needed files from mass storage directories, execute REVERT, make comparison plots of the HP versus the REVERT processed data, produce a listing of the terminal dialog, and store the files away. A working copy of the 800 or so plots for each file is produced on NIPS (a high volume text and graphics printer), and an archive copy, on fiche, resides in project Q/A files. The REVERT listing produced by each run is named RECxxxx, where the xxxx is the last four digits of the B-file name, and is stored in directory .SFT:REC. A listing of the skeleton file of RVCONTROL and a similar file used for generating plots, PLTCONTROL, is included in Appendix A).

RVCONTROL will process four B-files with no user intervention after the file names and dates are entered. In practice, the user could process 12-16 files in a day on the LTSS, and still be free for other work most of the time. Each B-file processed used about 6-10 minutes of CDC-7600 cpu time, with elapsed time dependent on priority and machine traffic (some files took most of a day). Many runs were made overnight or over weekends, when time-sharing was more efficient. Table 4.5-1 is the record of all REVERT runs. All were run under BCON/RVCONTROL. The "RVREC" column indicates the terminal dialog log-file, which is named RVRECmdds, where mdds is the date the run was made, and S is a sequence letter, needed because usually more than one run was made each day. "FRAMES" indicates how many licenses were in the B-file, and how many frames were plotted. "HPDB-file" indicates which database file was used. All final runs were made with REVERT version 11. The "comments" field describes phenomena noticed on the diagnostic plots while they were being scanned for errors.

Note that HPDB15E was only used for one file with a strange name, BNSG24. After all the B-files had been run, and the R-files were being transposed into REVERTed L-files, it was discovered that NSG245 and NSG246 were missing. The problem was traced to a lack of a temperature reference license (VWTCLC) in HPDB15D. Rather than reprocess and retranspose all licenses since the NSG's were turned on, we merged together the HP L-files for these gages and their temperature reference, SGT244. The resulting ASCII file was then converted to binary with MFAB, and the new B-file, BNSG24, was processed using the corrected database, HPDB15E. There were, of course, only three frames in the diagnostic plot file. This points up another capability of the processing system. We can reprocess any license or group of licenses at any time if a different calibration is desired, etc.

Table 4.2-1. List of REVERT data base files.

<u>Base No.</u>	<u>HP Dump File</u>	<u>Octopus List File</u>	<u>Octopus Data File</u>
1	HPTP800731	LIST800730	HPDB800730
2	HPTP800814	LIST800814	HPDB800814
3	HPTP800922	LIST800919	HPDB800919
4	HPTP800117	LIST801016	HPDB801016
5	HPTP810119	LIST780805	HPDB780805
6	HPTP810313	LIST810226	HPDB810226
7	HPTP810402	--	--
8	HPTP810409	LIST810409	HPDB810409
9	HPTP810418	--	--
10	HPTP810625	LIST810625	HPDB810625
11	HPTP811130	LIST811130	HPDB811130
12	HPTP811215	LIST811215	HPDB811215
13	HPTP811223	LIST811222	HPDB811222
14	HPTP820114	LIST820114	HPDB820114
15	HPTP820323	LIST820324	HPDB820324
16	HPTP820413	LIST820413	HPDB820413
17	HPTP820701	LIST820701	HPDB820701
18	HPTP820819	LIST820819	HPDB820819
19	HPTP821118	LIST821119	HPDB821119
20	HPTP830105	LIST830106	HPDB830106
21	HPTP830428	LIST830428	HPDB830428
22	HPTP831024	LIST831024	HPDB831024

Table 4.5-1. Record of final REVERT runs.

B-FILE	RVREC	FRAMES	HPDB FILE	COMMENTS
B44365	0420C	744	15	
B44382	0420C	745	15	NET103,NET104 on at 44376
B44406	0420C	745	15	no data on MBI04,05,06,11. shift in RTD's @44387.
B44421	0421A	745	15	2 deg drop in SAT001 @ 44418. MBI04, 5, 6, 11 excitation on @ 44417. Many lost traces @ 44419. AFM001 HP data starts.
B44440	0421A	743	15	HP AFM001 coefficients corrected @ 44424.
B44458	0421A	742	15	Power loss on canister 17 @ 44444. HP RX parameters in, data starts @ 44451.
B44478	0421A	751	15	HP RX parameters changed @ 44473. SSR's on @ 44466. CWE022 on @44477. CSG's off @ 44466.
B44496	0421B	751	15	CSG s on @ 44481. HP DPM data starts @ 44486.
B44516	0421B	751	15	GCE023 missing. NAT002,NHH's,NHT's on @ 44498. GCE03* offscale @ 44499. CHW171 off 44501-44512. HP MBI10* on @ 44515.
B44532	0421B	751	15	Many GXE's falling.
B44549	0421B	750	15	GCE044 missing. Power loss CHW15 @ 44541.
B44572	0420A	750	15	Node 1 down 44560-44570.
B44610	0421C	742	15	NSG032 offscale, SGT011,021 off @ 44585. Node 1 down @ 44605.
B44648	0421C	740	15	NSG's offscale or zero. RTD020 off. RTD000 out @ 44618. SCT165,166 stop @ 44615.
B44699	0421C	740	15	Air flow to 1/2 @ 44654.
B44742	0420A	741	15	Air flow to full @ 44705. MBI084 on @ 44725.
B44780	0428B	752	15	
B44815	0428B	737	15	CSG22*'s on @ 44781. Air flow to 1/2, SSR001,002,005 FAIL @ 44795.
B44857	0428B	739	15	SSR002,005 on @ 44835. NSG,CSG200's off @ 44842. Air flow to full @ 44845.
B44885	0428B	740	15	Air flow off @ 44857, 1/2 @ 44876, full @ 44878, 1/10 @ 44884. GBE,GCE0*'s off @ 44870.
B44925	0514A	757	150	
B44965	0514A	756	150	HP RX parameter change @ 44940.

Table 4.5-1. Continued.

B-FILE	RVREC	FRAMES	HPDB FILE	COMMENTS
B45005	0503A	801	15B	RX head TC's installed @ 45005
B45036	0503A	837	15B	CWT's installed 45015-45030. REVERT CWT162 missing (DATEQU=45006.43)
B45065	0503A	838	15B	REVERT MBI09's missing. CWT082 drifting. HP CWT's on @45054. Step in HP RX's @ 45056.
B45077	0503A	832	15B	REVERT MBI09's present.
B45082	0503B	832	15B	
B45117	0503B	834	15B	NSG's off @ 45112.
B45136	0503B	833	15B	CSG, NSG200's on 45129. HP AFM001 Parameters wrong. AFM201 on.
B45148	0503B	832	15B	Air flow to 1/2 @ 45145.
B45162	0503C	832	15B	Air flow to 1/4 @ 45153. HP RX Params. in @ 45152.
B45188	0503C	834	15B	Air flow to full @ 45165. HP AFM201 Parameters fixed @ 45177.
B45221	0503C	841	15B	Many channels out 45191-45202. REVERT CWE01-05 out.
B45261	0503C	836	15B	CSG200's out until 45256.
B45291	0503D	832	15B	SGT231,234,244 on. FMS052 Drifting.
B45329	0503D	831	15B	
B45364	0503D	829	15B	
B45397	0509B	830	15D	FMS052 off @ 45375. Step in all CWT's @ 45391.
B45423	0509B	778	15D	Canisters removed, CDG's installed.
B45458	0509B	684	15D	CDG071,072 on.
B45498	0509B	637	15D	
B45531	0514B	600	15D	
B45542	0514B	593	15D	
B45583	0514B	603	15D	5 degree pulses on NAT003, SAT003.
B45633	0514B	603	15D	END OF TEST @ 45607.5
BNSG24	NSG2	003	15E	Special run, NSG24's

Figure 4-1. Block diagram of data management system.

Figure 4.2-1. An example of the Item name file.

IN13 4/26/83
MINUS SIGNS MARK LOCATIONS
OF REFERENCE CHANNELS

NAMES IN H-P FILE HAVE
6 CHARACTER MAXIMUM

LCNMBR	1	LCDESC	2	PDTYPE	3	LCOSTR	4		5
DATEIN	7	DATEOU	8	DATEMO	9	DVM	10		2
NRAVE	11	TLAST	12						
MTSLGP	13	MTINTR	14						
TCOHMS	13	TCCDEF	14	YCREFC	-15	TCOC	16		13
ESNL0C	13								
RXESLC	-13	RXR0DL	14						4,13
RXXCP1	15	RXXCP2	16	RXXCP3	17	RXXCP4	18		4
RXXCP5	19	RXXCP6	20	RXXCP7	21	RXXCP8	22		4
RXXCP9	23								4
RXXCC1	24	RXXCC2	25	RXXCC3	26	RXXCC4	27		4
RXXCC5	28	RXXCC6	29	RXXCC7	30	RXXCC8	31		4
RXXCC9	32								4
RXTLC0	-33	RXTLC1	-34	RXTLC2	-35	RXTLC3	-36		4,13
RXTLC4	-37	RXTLC5	-38	RXTLC6	-39				4,13
RXDIT0	40								4
RXPCL4	41	RXPCL5	42	RXPCL6	43	RXPCL7	44		4
RXPCL8	45	RXPCL9	46						4
RXT0C0	47	RXT0C1	48	RXT0C2	49	RXT0C3	50		4
RXT0C4	51	RXT0C5	52	RXT0C6	53				4
RXPCL1	54	RXPCL2	55	RXPCL3	56				4
RXMT01	61	RXMT02	62	RXMT03	63	RXMT04	64		4
RX0C	68	RXCASE	69						4
RTR0	13	RTCA	14	RTCB	15				
SD0C	13								
LDSL0P	13	LDINTR	14						
MDPR0H	13	MDPAR1	14	MDPAR2	15	MDPAR3	16		
MDPAR4	17	MDPAR5	18						
VMSF	13	VMZLR	14	VMM	15	VMT0	16		10 FOR DB > 4/12/82
VNR0	17	VMTCLC	-18						10,13 DB > 4/12/82
HXESLC	-13	HXWIRL	14	HXSEN	15				9,13
HXTEMP1	16	HXTEMP2	17	HXTEMP3	18	HXTEMP4	19		9
HXTEMP5	20	HXTEMP6	21	HXTEMP7	22				9
HXTLC1	-23	HXTLC2	-24	HXTLC3	-25	HXTLC4	-26		9,13
HXTLC5	-27	HXTLC6	-28	HXTLC7	-29				9,13
HXMTY1	30	HXMTY2	31	HXMTY3	32	HXMTY4	33		9,12
HXMTY5	34	HXMTY6	35	HXMTY7	36				9,12
HXTEC1	37	HXTEC2	38	HXTEC3	39	HXTEC4	40		9,12
HXTEC5	41	HXTEC6	42	HXTEC7	43				9,12
HX0C	44								9
PNC0	13	PNC1	14	PNC2	15	PNC3	16		
PNC4	17								
SYPR0H	13	SYPAR1	14	SYPAR2	15	SYPAR3	16		
SYPAR4	17	SYPAR5	18						

5.0 REVERT DATA BASE AND ALGORITHM DESCRIPTION

An HPDB-file is in random access (as opposed to sequential access), form so data can be quickly retrieved from any desired location during a processing run. The last 8 words consist of information describing the database: the number of coefficient blocks in the file, the name of the file when it was first created, the name of the last HPTP-file merged into this file, the time of day and date REVERT last modified this file, and the 6-digit date that was merged with the file name. The rest of the file consists of 100-word blocks of instrument descriptors. The content of these 100-word blocks is shown in Table 5-1. The final version of the HPDB-file, HPDB15E, is listed on fiche as Appendix B.

The first 12 words of the 100-word block have the same definition regardless of instrument type. Most of these parameters are straightforward. DATEIN, DATEOU, and DATEMO (locations 7, 8, 9) are particularly important as they determine if a particular parameter set is applicable to a given data point. The Julian date of the data point must be after the date the instrument was installed, DATEIN, before the date the instrument was removed, DATEOU, and, to provide more general control, after the date the parameters first become effective, DATEMO. (In the NTS version of the database, DATEMO was defined as the date the parameter set was last modified, a slightly different connotation.) DATEMO is used in the present database to switch from one parameter set to another, and, by inserting a very late date, to "turn off" an incomplete data set so it cannot be used. In switching from one parameter set to another, DATEMO does not have to be exactly the date/time of the last data point of the first set, nor the first data point of the last set, but may be an arbitrary date/time value between the two.

TOOLD1, TOOLD2, and TOOLD3 (locations 10, 11, 12) are used by GCBFR in the selection of data values from reference licenses processed in earlier passes. These data are usually excitation voltages or temperatures, and are scanned immediately before the license referencing them. The TOOLD values (in minutes) determine if the values found are close enough in time to be relevant to the RX data point in question. To speed processing, if the values found are within 2 minutes of the time needed for the current conversion, the TOOLD

parameters are not used and the found values are used as is, without interpolation. If neither bracketing value passes the 2-minute criterion, both must pass the TOOLD criterion. Thus data can be lost (not converted) if one bracketing value is slightly over the 2-minute criterion and the other is slightly over the TOOLD criterion, even with a TOOLD parameter of 1440 minutes (one day). This happens more often than one might suspect because the HP-1000 scanning algorithm only considers the preceding reference value.

5.1 Pass One and Pass Two Devices (ES, SD, WT, LD, RT, PN, and TC)

Pass one and pass two devices are the same in that they require no temperature correction, and parameters for the HPDB-files were copied directly from the HP1P-files. This can be seen by comparing Table 5-1 with Fig. 4.2-1. The TOOLD values are not used for pass one devices and appear as zeros in the HPOB-files.

5.1.1 Excitation and Status Devices (ES and SD)

The ES's and SD's are similar in that both are in the proper units, and only require an additive offset value. The ES's are the excitation voltages for those instruments which use linear potentiometers as a sensing transducer (initially all RX's and WX's, but see Section 5.2.3). The offset values, parameter 13, are set to zero for the ES's, but set to -900. for most of the SD's. The SD's are Status Devices whose outputs are used as logic levels, biased by a negative offset. They indicate the presence or absence of such things as alarms or power, and are not used in processing the data.

5.1.2 Watt Meters and Linear Devices (WT and LD)

The WT's and LD's are both linear devices, and require a slope (location 13) and intercept (location 14) for conversion to engineering units. In fact, the intercepts are set to zero for all of the WT's. The WT's are Watt meters, monitoring power consumption of the electrical heaters and tunnel lighting. The LD's include voltages of various power supplies, the air flow meters, the system standard references, the CWT's using wire resistance to measure convergence wire temperature, the ATM series of air temperature measurements, and the RBT series of reference block temperatures (never used).

The algorithms for the WT's and LD's are identical in form, only the names of the variables are different (see Table 5-1). For the WX's, we have:

$$\text{CONV} = \text{WTSLOP} * \text{RAW} + \text{WTINTR}$$

While for the LD's we have:

$$\text{CONV} = \text{LDSLOP} * \text{RAW} + \text{LDINTR}$$

In both cases, CONV is the converted value, and RAW is the raw value.

The CWT's that were LD type devices, as opposed to those that were PN device types, deserve special mention as they were a novel approach to temperature correction of the convergence wires. These wires stretch across distances of 3 to 8 m and the temperature of the wire varies from place to place over this distance. The total thermal expansion of the wire, for which we must correct, is the integral of the varying differential expansion along the wire's length. But this is just the (constant) expansivity of the wire times the integral of the temperature along the wire. The integral of temperature is, in turn, a linear function of the total electrical resistance of the wire. The slope is just the temperature coefficient of resistivity. The slope and intercept were obtained by measurement of the wire's resistance over a range of known temperatures (Patrick et al., 1984c).

5.1.3 Resistance Temperature Devices (RT)

The RT's are resistance temperature devices, in this case, platinum resistance thermometers, generally used to monitor the temperatures of a number of large copper blocks which form the reference junctions for the TC's. (See the discussion of the TC's following.) Three parameters are used in the algorithm: RTRO, RTCA, and RTCB, (locations 13, 14, and 15). We first calculate:

$$\text{TEMP} = \text{RTCA} * \text{RTCA} - 4.0 * \text{RTCB} * (1.0 - \text{RAW} / \text{RTRO})$$

Then if TEMP is not less than zero,

$$\text{TEMP} = \text{SQRT} (\text{TEMP})$$

$$\text{CONV} = (\text{TEMP} - \text{RTCA}) / (2.0 * \text{RTCB})$$

5.1.4 Polynomial Devices (PN)

The PN's were BWT and CWT thermistors used to define the vertical and horizontal variation of air temperature in the canister drift. They were mounted on cross-shaped frameworks of PVC pipe at two locations in the canister storage drift. The conversion algorithm was a fourth order polynomial expansion using four parameters (locations 13-17) as follows:

$$\text{CONV} = (((\text{PNCD} * \text{RAW} + \text{PCN1}) * \text{RAW} + \text{PCN2}) * \text{RAW} + \text{PCN3}) * \text{RAW} + \text{PCN4}$$

If RAW = 0, CONV = PCN4, the constant term.

5.1.5 Thermocouples (TC)

The thermocouples used were Type K (Chromel-Alumel), with junctions grounded in an Inconel 600 sheath, and using MgO insulation. Instead of providing reference junctions at some fixed temperature, the reference junctions were mounted on copper blocks in semi-insulated boxes, providing the same reference junction temperature to all TC's terminated on the block. This temperature was measured by an RTD. Thus TC's are pass two devices since they require the result of a pass one device (an RTD) for their conversion. TOOLD1 is used in reference to the RTD temperature, and is set to 20 minutes for all the TC's. TOOLD2 and TOOLD3 are not used.

FIITC calls the routines GCBFR and RVAL which obtain the reference temperature, then calls TEMPK with the RTD temperature, RT, and the voltage, UV, of the thermocouple. TEMPK contains both the forward and backward thermocouple functions of voltage versus temperature. It first converts the RTD reference junction temperature to a voltage and adds it to correct the TC voltage:

$$E = UV + RT * (VP (1) + RT * (VP (2) + RT * (VP (3))))$$

where E is the corrected voltage and the VP(1) are coefficients built into TEMPK. E is then converted to temperature via a quartic. There are actually four sets of quartic coefficients, each applicable to a different range of E (Patrick et al., 1984c).

$$T = TP(1) + E*(TP(2) + E*(TP(3) + E*(TP(4) + E*TP(5))))$$

5.2 Pass Three Devices (WX, VW, RX)

The pass three devices include all the geotechnical instruments, measuring the rock response in terms of displacements and stress changes.

5.2.1 Convergence Wire Extensometers and Fracture Monitors (WX)

The convergence wire extensometers (CWE's) and fracture monitors (FMS's) are somewhat different in design, but use the same form of correction algorithm, and so share a common correction subroutine, FITWX. The devices both measure movement of one point on the interior surface of a tunnel relative to some other point on the tunnel surface. In the case of the FMS's, the two points are close together on opposite sides of a known fracture, and the measurement is made in three dimensions using three transducers. For the CWE's, the points are on opposite sides of the tunnel, the differential movement is carried across the tunnel by a tensioned steel wire, and only the change in distance between the two points is measured. The sense of the measurement is such that increasing distance is a positive change. In the case of shear movement across fractures, a sketch of the manner in which the particular transducer was mounted to the rock is needed to infer the sense and orientation of the rock response. The "through hole extensometers", or THE's, are identical to the CWE's, except that the wire passes from the north wall of the north heater drift, across the north heater drift, through an NX borehole in the north pillar, across the canister drift, through another NX borehole in the south pillar, across the south heater drift, and finally, to the south wall of the south heater drift.

Both WX instrument types are exposed to tunnel air and are affected by changes in tunnel air temperature. The effect of temperature on the FMS's is small, less than 5.2 microns/degree Celsius. The effect on the CWE's is much

larger, about 100 microns/degree Celsius, and almost 400 microns/degree for the THE's. The temperature correction algorithm assumes the effect can be expressed as a linear combination of up to 7 temperature measurements at various locations.

Table 5.2.1-1 shows the installation, calibration, and performance history of the WX's by date and Julian Day. Because dedicated temperature sensors were installed some time after the initial installation of the CWE's and FMS's, two parameter sets are needed for each of these instruments. The sets are distinguished in an HPDDB file by appending an A or B suffix to the license name (the suffix is actually stored in parameter 100). In order to make use of the more powerful ALTER commands, the duplicate license is temporarily created with a unique name, and converted to the proper name at the end of the ALTER process. The names used were as follows:

<u>FIRST SET</u>		<u>SECOND SET</u>	
<u>FINAL NAME</u>	<u>ALTER NAME</u>	<u>FINAL NAME</u>	<u>ALTER NAME</u>
FMS0**A	FMS0**	FMS0**B	FMS2**
CWE0**A	CWE0**	CWE0**B	CWE2**
CWE1**A	CWE1**	CWE1**B	CWE3**

Note that the actual name of the instrument, as it appears in the data tapes and on plots or listings, does not change over the lifetime of the instrument, and does not contain the suffix.

5.2.1.1 Universal Parameters Locations (1-12)

TOOLD1 refers to the excitation voltage, and is set to 5 minutes for the WX's. TOOLD2 refers to instrument temperature which probably has a time constant of less than a minute for the CWT's, and several minutes for the FMS's. However, until JD45004, the instrument temperature was inferred from a nearby RTD, and the RTD's were unfortunately not included in the scan tables for the CWE's or FMS's. TOOLD2 is thus set to 1440 minutes, a full day, to ensure that data will be converted, at the risk of some inaccuracy. TOOLD3 is not used.

5.2.1.2 WX Specific Parameters

WXESLC (location 13) contains the license of the excitation voltage for the WX.

WXWIRL (location 14), is the wire length for the CWE's, and is not used for the FMS's

WXSEN (location 15) is a sensitivity factor in volts**2 per meter.

WXOC (location 44) is a constant primarily used to offset the data values so the initial values are zero. The instrument thus measures change since installation.

WXTLC1-7 (locations 23-29) is a set of seven licenses of temperature references. Not all must be used, as the code stops when it finds a blank license in the list. Thus if the first one is blank, no temperature correction occurs.

WXTMU1-7 (locations 30-36) and WXTOC1-7 (locations 16-22) are multipliers and offsets for the reference temperatures. Since the reference temperature was not in contact with the WX, at least before JD45004, the true reference temperature is assumed to be a linear function of the measured reference temperature. The values were chosen by studying the relationship between the nearby temperature and the true temperature while both were available, after JD45004. That study showed that the relationship changed with time, as the ventilation rate and power levels in the test changed, and no increase in accuracy would be gained by using a multiplier other than one. The possibility of predicting the true temperature by a linear combination of up to seven nearby temperatures, was not pursued, though it could be still, since the data were acquired and are available. The offset WXTOC is subtracted and thus, with a multiplier of 1.0, becomes simply the initial temperature, i.e., the temperature at JD44342, when first readings were obtained.

WXTEC1-7 (locations 37-43) are the thermal expansion coefficients, in terms of an expansivity times a length, and have units of microns per degree Celsius.

Only one value of WXTLC was used for the FMS's. Two were used for the CWE's, but the same license, multiplier, and offset was entered for both. Different values of WXTEC were entered, corresponding to the instrument head and wire, respectively.

5.2.1.3 WX Algorithm

The parameter block carries seven sets of temperature multiplier, WXTMU, temperature offset, WXTOC, temperature reference license, WXTLC, and thermal expansion coefficient, WXTEC. The algorithm loops over this set until a blank reference temperature is found, adding corrections as it goes. The correction for each step of the loop is obtained as follows:

$$WXKCCD = RAW / ESVAL$$

where WXKCCD is a working value, RAW is the raw value, and ESVAL is the excitation voltage. Then,

$$VAL = WXKCCD * WXSEN + WXOC$$

computes an uncorrected value of displacement in meters. We then enter the temperature correction loop, calculating

$$DTEMP = (\text{reference temperature}) * WXTMU(i) - WXTOC(i)$$

and,

$$VAL = VAL + DTEMP * WXTEC(i)$$

Upon exiting the loop, VAL is the corrected displacement.

5.2.2 Vibrating Wire Stressmeters (VW)

The VWSM's consist of stiff hollow steel cylinders across the interior of which a steel wire is stretched diametrically. Upon installation, the cylinders are clamped in a 1.5 inch borehole with cylinder and borehole axes

parallel. As rock stress increases, the load on the cylinder decreases the tension in the wire, and lowers its resonant frequency of vibration. The raw values read by the computer are 4-digit integers equal to ten times the period of vibration in microseconds.

The data followed a unique path. Emerging from the manufacturer-supplied data logger in RS-232 protocol, it bypassed the HP scanners, and was transmitted directly to the computer via modem. The path was not operational from the beginning of the test, JD44330, to about JD44569. During this time the data were printed on a teletype. The teletype record was subsequently keypunched, and after some initial processing to change the format, became S-file SF000A/A (Patrick et al., 1981, pp 28-31).

All of the initial units failed and were replaced with an improved version (Patrick et al., 1981, pp 31-39). Temperature effects on an unclamped instrument, or an instrument clamped in a material of the same expansivity as the steel cylinder itself, are small. When clamped in a material of differing expansivity there is an effect, proportional to the expansivity difference. For the SFI-C, this effect was measured by the manufacturer on gages clamped in large samples of Climax stock quartz monzonite (CSQM) (Dutta et al., 1981). Table 5.2.2-1 shows the history of the VW devices.

5.2.2.1 Universal Parameters Locations (1-12)

TOOLD1 refers to a temperature measurement on the shallowest gage in each group of three. Since the gages are all within the rock, time constants are quite long, so TOOLD1 is set to 1440 minutes, or one day.

5.2.2.2 VW Specific Parameters

VWSF (location 13) Gage sensitivity factor, chosen according to how well the gage held its reading as installation (preload) forces are released. The value was 1.6 for gages with stable preload, 1.8 for gages that lost 5-10% of their preload, and 2.0 for gages which lost over 10% of their preload.

VWZLR (location 14) Gage reading in unloaded condition, measured just before the gauge was installed.

VMMM (location 15) Gage-rock thermal modulus, measured by the manufacturer in CSQM. A value of 1.55 gage units per degree Celsius is used for all gages.

VWTO (location 16) Initial temperature. Actually, the temperature 8-24 hours later to allow the gage to come into thermal equilibrium with the rock.

VWRO (location 17) Reading of the gage after equilibrium is reached.

VWTCLC (location 18) Temperature reference license. A thermocouple of the SGT series.

5.2.2.3 VW Algorithm

First, FITVW, calls GCBFR and RVAL to get the reference temperature, then subtracts VWTO to get the temperature change DT. The temperature correction is then applied to the initial gage reading, VWRO.

$$T1 = VWRO + DT * VMMM$$

then,

$$T2 = RAW$$

$$CONV = 1.7842E14 + VWSLOP * (1 / (T1 * T1) - 1 / (T2 * T2))$$

5.2.3 Rod Extensometers and Hole Deformation Gages (RX)

The rod extensometers have a fairly complicated history, which varies between the different groups of instruments. There are five groups, identifiable by the alpha part of their license names as MBI, GAE, GBE, GCE, and GDE. The instruments are installed in boreholes named by the alpha part and the first two digits of the numeric part of the license. There are between 3 and 6 instruments per borehole, and the boreholes are 5-15 meters

deep (Brough and Patrick, 1982). Each instrument measures changes in the distance from the collar of the borehole to an anchor located at some depth in the borehole. The last digit of the license is the anchor number, sequenced from the borehole collar. The distance measurement is made on the collar end of a rod which reaches from the anchor to the borehole collar and is held in tension by a spring. The resolution of the measurement is on the order of 0.03 micrometers, however friction in the rods and other factors limit accuracy to about 50 micrometers. By convention, an increase in the anchor-collar distance is considered a positive change.

The MBI group, originally intended to monitor the effects of mining the canister drift, were installed in boreholes drilled from the North and South drifts toward the canister drift. The measuring heads were refurbished and recalibrated for use during the heated phase of the SFT-C, but the anchors and rod tensioning components were left as is. The MBI rods are of carbon steel, while all other RX's use Superinvar, an alloy designed to minimize thermal expansion. These other RX's are installed in vertical boreholes drilled in the canister drift floor. The GBE and GCE groups consist of six boreholes each and are located in the middle section of the drift near the heat producing canisters, while the GAE and GDE groups consist of one borehole each, and are located at the far ends of the drift where temperature effects in the rock are less.

Table 5.2.3-1 shows the installation, calibration, and performance history of the rod extensometers by both date and Julian day. Because the installation of the RX head TC's requires a new parameter set for each RX operating at that time, licenses GAEO**, GBE2**, GCE21*, GCE22*, GCE23*, GCE44*, GCE45*, GCE46* are entered twice. An A suffix designates parameter sets applicable before the new TC's were in place, a B suffix after (the suffix is stored in parameter 100). In order to make use of the more powerful ALTER commands, these instruments are created with different license names and converted to the proper ones at the end of the ALTER process. In general, since the licenses in the initial data base were selected from the HPTP files going backward in time to ensure that the most recent (and presumably best) parameters were obtained, the second set was already existing and the first

set had to be created anew. Data common to both was then copied from the second set to the first. The names used were as follows:

FIRST SET		SECOND SET	
FINAL NAME	ALTER NAME	FINAL NAME	ALTER NAME
GAE01*A	GAF11*A	GAE01*B	GAE01*B
GBE2**A	GBE3**A	GBE2**B	GBE2**B
GCE21*A	GCE31*A	GCE21*B	GCE21*B
GCE22*A	GCE32*A	GCE22*B	GCE22*B
GCE23*A	GCE33*A	GCE23*B	GCE23*B
GCE4**A	GCE5**A	GCE4**B	GCE4**B

The CDG's consisted of strain-gaged proving-ring assemblies, with the proving-rings clamped into canister emplacement holes after the canisters and liners had been pulled at the end of the test (Patrick et al., 1984b). The object was to measure borehole closure during cool-down. Two gages in canister hole CEH07 were not in contact with the rock. They were suspended in the hole, one with no load, and one with a constant load, to document the effects of possible strain-gage creep and of temperature changes on the gage itself. The thermal expansion coefficients and calibration temperatures of these gages were set to zero, so no correction would be applied, but a head temperature license was provided so the data would not be defaulted to -9999.

5.2.3.1 Universal Parameters (Locations 1-12)

TOOLD1 refers to the RX excitation voltage and is set to the comparatively short time of 1 minute. This defaults to the minimum value of 2 minutes (see Section 5.0). For those RX's which have no excitation reference, TOOLD1 is not used. Thus for GBE21*, GBE22*, GBE23*, GCE21*, GCE22*, and GCE23*, TOOLD1 may have any value.

TOOLD2 refers to the RX head temperature or the CDG instrument temperature. Before installation of the head temperature TC's (02/03/82), the head temperature was inferred from nearby tunnel air temperature measurements. Unfortunately, those licenses were not listed in the RX scan tables, and were scanned much less frequently than the RX's. Thus TOOLD2 is

set to 1440 minutes, although the thermal time constant of the head is about 30 minutes. Although this introduces some error into the temperature compensation process, it is necessary to lower the data rejection rate. For the CDG's the TOOLD values were never set and are zero. The minimum value of 2 minutes is thus used (see Section 5.0). This may cause some lost data, if the reference temperature scan was not made immediately before the CDG scan.

TOOLD3 refers to TC measurements at each RX anchor. Since these are deep in the rock, thermal time constants are long, and TOOLD3 is set at 1440 minutes, a full day. TOOLD3 is not used for CDG's.

5.2.3.2 RX Specific Parameters

RXESLC (location 13) contains the license of the excitation voltage for the RX. When the 200-series transducers were installed, GBE and GCE 21*, 22*, and 23* were fitted with transducers for which excitation voltage measurements were not required. For these instruments RXESLC should be blank. As mentioned above, TOOLD2 is ignored in these cases. For the rod extensometers, the excitation license name is the same as the RX names, with the last number set to 0. For the CDG0**, it is CDE0**'s. To simplify the ALTER process, the alpha part of the name is changed temporarily to *EE for the G*E's, and to MBE for the MBI's.

RXRODL (location 14) This location is not used. The rod length data are taken from RXDIT0-6 (see below).

RXKCP1-RXKCP9 (locations 15-23) and RXKCC1-RXKCC9 (locations 24-32) comprise the calibration table on which the measured voltages are interpolated to obtain distances. RXKCP* is a calibration position set by a precision shim or block, while RXKCC* is the reading obtained on the instrument at that position. Calibrations were performed on the dates shown in Table 5.2.3-1 and are required whenever the transducers are changed or disturbed. At these times the license name has always been changed, so only one calibration set is required for each license. The calibration is only measured over a few millimeters in the center of the range of the instrument, therefore values for the limits of the instrument's range must be extrapolated. The numbers in the

HPDB file were obtained from the DAS Manager, either directly, or copied from an HPTP file, in which case the data were entered by the DAS Manager, or his alternate, on the HP-1000 system.

RXTLC0-RXTLC6 (locations 33-39) are license names of temperature reference channels for the instrument. The first is the head temperature, and changes when the head TC's were installed. Otherwise the names are constant for a given borehole even through the different instrument series' for that borehole. The numeric part of the name is the same as the numeric part of the RX name. For the G*F's the alpha part is *ET. For the MBI's in the North drift (boreholes 1, 2, 3, 8, 9, 10) the alpha part is NET. For those in the South drift (boreholes 4, 5, 6, 11, 12, 13) it is SET. A last digit of 0 is used for a head temperature after the head TC's were installed. Before that the name will be a RTD. For the CDG's only the first location is used, the instrument temperature (CDT0xx).

RXDIT0-6 (locations 40-46) These are not used for the CDG's, but, for the rod extensometers, are each the distance from the collar of the instrument to the reference temperature device in question. Since the TC's were mounted on the anchors, this is also the rod length to that anchor. RXDIT1-6 were read from the dump tape as RXPCL4-9 (see below).

RXT0C0-6 (locations 47-53) are the readings of the reference temperature channels at the time the instruments were initially calibrated. Only RXT0C0 is used on CDG's.

RXPCL1-3 (locations 54-56) and RXMTC1-3 (locations 61-63) are Physical Component Lengths and Material Thermal Coefficients of components in the instrument head of the rod extensometers. For the CDG's RXPCL(1) is set to 1.0 and RXMTC(1) is given in units of micron/degree Celsius. RXPCL4-7 are not used.

RXMT04 and RXMT05 (locations 64 and 65) are the Thermal Expansion Coefficient (TEC) adder and multiplier, respectively, used to provide a TEC for the Superinvar rods which is a linear function of temperature, according to the expression:

$$TEC = RXMTC4 + RXMTC5 * T$$

where T is the temperature. For the G*E's, RXMTC4 is $-5.495E-07$, and RXMTC5 is $+3.3E-09$. These values were the result of measurements on samples of the rods (Patrick et al., 1983) For the MBI's and CDG's the adder and multiplier were set to 0.0 and 1.0, respectively.

RXMT6 and RXMT7 (locations 66 and 67) are a multiplier and adder, respectively, which are applied to the measured temperature of the reference license RXTLCO. This permits calculation of true head temperature as a linear function of a nearby reference temperature that is not in contact with the head. For all instruments after JD45004, the multiplier is set to 1.0, and the adder to 0.0. For instruments operating at earlier times, the values were chosen by a least squares fit of values from nearby instruments after JD45004, to values from the reference in contact with the head.

RXOC (location 68) is an offset value to bring the value at the start of the test to zero, so the instrument measures the change since the beginning of the test (or instrument installation, since many instruments were installed well after the test began, e.g., the 200 series G*E's and the CDG's.).

5.2.3.3 RX Algorithm

The FITRX routine proceeds by first dividing the raw value by the excitation voltage:

$$RXKCCO = RAW / ESVAL$$

Then we interpolate in the calibration table to get a uncorrected displacement value in meters. The head temperature is then obtained as a linear function of the reference temperature.

$$HDT = (\text{reference temperature}) * ASS + BSS$$

where ASS and BSS are RXMTC6 and RXMTC7, respectively.

The temperature change since calibration is obtained,

$$DHDT = HDT - RXTOC(9)$$

and we compute the head correction, by looping over the three types of head material

$$VAL = VAL + RXPCL(i) * RXMTC(i) * DHDT \quad i=1,3$$

The rod temperatures are loaded, and we loop over $i=2, n$, where n is the number of anchors plus one (not needed for COG's),

$$\begin{aligned} DL &= RXDTT(i) - RXDTT(i-1) \\ DT &= T(i) - T(i-1) \\ DTO &= RXTOC(i) - RXTOC(i-1) \\ DDT &= DT - DTO \\ RMPP &= DTO / DL \\ RMP &= DT / DL \\ BP &= T(i-1) - RMP * RXDTT(i-1) \\ BPP &= RXTOC(i-1) - RMPP * RXDTT(i-1) \\ TF &= RXMTC(5) * DT \\ BPPP &= BP - BPP \\ RMBS &= RXMTC(5) * BP + RXMTC(6) \\ TF &= TF * (.33333 * DDT + .5 * BPPP) \\ VAL &= VAL + DL * (TF + RMBS * (.5 * DDT + BPPP)) \end{aligned}$$

Upon exiting the loop, VAL is the temperature-corrected displacement.

Table 5-1. Instrument descriptor block coefficient definitions.

Item name	Data type*	Descriptor block index	Data description
LCNMBR	I	1	Logical channel number
LCDESC	A	2	License Plate
PDTYPE	A	3	Physical device type
LCDSTR	A	4-6	Channel descriptor string
DATEIN	A-R	7	Date device installed
DATEOU	A-R	8	Date device removed
DATMO	A-R	9	Date coefficients modified
TOOLD1	-R	10	Time limit 1
TOOLD2	-R	11	Time limit 2
TOOLD3	-R	12	Time limit 3
WTSLOP	R	13	Slope coefficient
WTINTR	R	14	Intercept
TCOHMS	R	13	TC resistance
TCCOEF	I	14	TC quartic coefficient set
TCREFC	I-A	15	TC reference channel
TCOC	R	16	TC offset constant
ESWLDC	R	13	Excitation wire loss offset
RXESLC	I-A	13	RX excitation channel
RXRODL	R	14	Rod length, meters
RXKCP1-9	R	15-23	Calibration position 1-9
RXKCC1-9	R	24-32	Calibration reading 1-9
RXTLCO-6	I-A	33-39	Temp. ref. channel 0-6
RXDTT0-6	R	40-46	Distance to temp reading
RXTOCO-6	R	47-53	RX calibration temperature
RXPCL1-3	R	54-56	Physical component length 1-3
RXPCL4-7	R	57-60	Not used
RXMTC1-3	R	61-63	Thermal expansion value 1-3
RXMT(4)	R	64	CTE temp adder (B)
RXMT(5)	R	65	CTE temp multiplier (A)
RXMT(6)	R	66	Head temp multiplier (ASS)
RXMT(7)	R	67	Head temp adder (BSS)
RXOC	R	68	RX offset constant
RTRO	R	13	Reference resistance
RTCA	R	14	Coefficient A
RTCB	R	15	Coefficient B

Table 5-1. Continued.

Item name	Data type*	Descriptor block index	Data description
SDOC	R	13	SD offset constant
LOSLOP	R	13	Linear device slope
LDINTR	R	14	Linear device intercept
MDPRON	A	13	Misc. processor name
MDPAR1-5	I	14-18	Misc. processor param. 1-5
VWSF	R	13	IRAD gage sensitivity
VWZLR	R	14	Zero load reading
VWMM	R	15	Gage-rock thermal modulus
VWTO	R	16	Initial temperature
VWRO	R	17	Initial set gage reading
VWTCLC	I-A	18	Gage temperature channel
WXESLC	I-A	13	WX excitation channel
WXWIRL	R	14	WX wire length, meters
WXSEN	R	15	Sensitivity, volts**2 per meter
WXTOC1-7	R	16-22	WX offset temperature 1-7
WXTLC1-7	I-A	23-29	WX temperature ref. channel 1-7
WXTMU1-7	R	30-36	Temperature multiplier 1-7
WXTEC1-7	R	37-43	Thermal expansion coefficient 1-7
WXOC	R	44	WX offset constant
PNCO-4	R	13-17	Polynomial coefficient 0-4
SYPRON	A	13	System processor name
SYPAR1-5	I	14-18	System processor param. 1-5

*I is integer; A is BCD (ASCII) characters; R is real floating point; A-R is BCD in the NTS files and real floating point in the HPDB; -R is real entered by ALTER only; I-A is integer channel number in HPTP converted to BCD license plate in HPDB.

Table 5.2.1-1. WX history.

DATE	JULIAN DAY	COMMENTS
04/12/80	44342	First raw readings, all CWE's, THE's and FMS's
05/19/80	44379	CWE061-122 stowed for fuel emplacement
05/21/80	44381	CWE061-122 reinstalled
05/27/80	44387	CWE061-122 stowed for fuel emplacement
05/28/80	44388	CWE061-122 reinstalled
07/24/80	44445	Replaced linear pot. on CWE102, dividing network on CWE022.
09/17/80	44500	Reversed output of CWE071, replaced pot. on THE002.
06/18/80	44501	Rezeroed pot. on THE002.
05/21/81	44746	Removed, cleaned & reinstalled pot on CWE031, set offset at 0.006253 V.
01/19/82	44989	CWT's and FMT's installed on CWE's and FMS's
02/03/82	45004	First readings with new temp. data.

Table 5.2.2-1. VW history.

DATE	JULIAN DAY	COMMENTS
<hr/>		
03/20/80	44319	Initial installation complete.
04/01/80	44331	First raw readings on teletype (SF000A/A)
04/27/80	44357	System clock changed from PST to PDT.
08/07/80	44459	CSG022 reading 0000.
08/13/80	44465	CSG013 reading 0000.
08/14/80	44466	System taken down to test interface. Erratic behavior of CSG022 and CSG023.
08/29/80	44481	System up on TTY. CSG022,23 reading 0000.
09/30/80	44513	"free" VWSM, CSG024, hung in borehole CSG02.
11/14/80	44558	CSG024 failed.
11/26/80	44570	System up on DAS, TTY output ended.
12/19/80	44563	CSG's removed.
06/17/81	44773	CSG2**'s and NSG241, 242, 243 installed.
06/25/81	44781	CSG2**'s, NSG241, 242, 243 first readings.
10/27/82	45270	NSG23*'s, NSG244, 245, 246 installed.
11/01/82	45275	NSG23*'s, NSG244, 245, 246 first readings.

Table 5.2.3-1. Rod extensometer history.

DATE	JULIAN DAY	COMMENTS
02/19/80	44298	Initial installation
04/01/80	44331	Calibration complete
04/12/80	44342	First readings (on GAE's)
04/23/80	44353	All RX's operating
11/12/80	44556	MBI081 replaced by MBI084
09/24/81	44870	GBE's, GCE's removed due to pot failure. Recalibrated before removal. Replacement instruments will have 200 added to license numeric.
10/09/81	44887	GBE24*, GBE26*, GCE21*, GCE22*, GCE23* installed and calibrated.
10/12/81	44890	GBE24*, GBE26*, GCE21*, GCE22*, GCE23* first readings
10/30/81	44908	GBE25*, GCE24*, GCE25*, GCE26* installed, calibrated, first readings obtained.
01/27/82	44997	GBE21*, GBE22*, GBE23* calibrated
02/03/82	45004	First readings on RX head TC's
03/17/83	45411	GCE44*, GCE45*, GCE46* calibrated

6.0 STORAGE, PLOTTING, AND LISTING

6.1 R-files System

The SFT-C Data Management effort created a large number of codes, databases, and interface files. In order to ensure the traceability of the reported data, essentially all versions of each file were stored for future reference, and a voluminous paper file accumulated of notes, terminal dialogs, and other Q/A checks. In order to inspect the work, a capability for listing and plotting the large database and data files was required.

6.1.1 Archiving

The files were stored on the ENTERPRISE file transport system, using utility routine XPORT (Smith and Belles, 1981). The root directory is .SFT and is duplicated under user numbers 138000, 348500, 393200, 746394, and 760075. The root uirectory contains 18 sub-directories with usage as follows:

B-FILES contains the 63 B-files produced by MFAB2, including the 18 intermediate and the 45 final B-files.

BRDINT contains the 27 BREAD interface files.

CODES contains 26 files. Ten are source files and 13 are executable files, for small codes used frequently, and for which storage in the LIB file seemed cumbersome. Also stored here are the two BCON "skeleton" control files and a library of subroutines used in the Data Management System, REVERTLIB.

DBRPT contains 28 listing files of "dump" tapes in a format developed by DAS personnel.

FIRSTLAST contains a set of 62 files which list the first and last data points for each license in selected R-files. The files are the result of running code BTOA6, and were used to find the first occurrence or last occurrence of a given license.

FLCOMB contains a working set of files merged from those in FIRSTLAST to develop a list giving the first and last times for each license.

HPDB contains 45 files of 4 types. There are the 22 files created from "dump" tapes to provide listings and to compare for changes from dump to dump. Next are six merged HPDB-files, including HPDB4/83M, the file on which all alter runs were made. Then we have 16 HPDB-files produced by ALTER runs using 16 versions of ALTER-files. And, finally, a special HPDB-file, HPDBZERO, which has zero values for all offset constants. A REVERT run was made with this HPDB-file on the first S-file, B44365, to compute the un-offset first readings of each pass 3 device. These first readings were then reversed in sign and entered as offsets, so the initial temperature-corrected reading would be zero.

HPTP contains the 22 "dump" files.

LIBS contains 80 files, each of which contain a dozen or so codes. There are four types. Files which are named SFTSymmdd or SFTCymdd are the libraries for the source and executable files of the codes in use on the date, Bymdd, that the library was created. A new library was made each time a new version of one of the codes was released for use. Files which are named SFTLIBn or SFTLIBnS are binary and FORTRAN source libraries of subroutines used in the above codes. There are 8 pairs of SFTLIB files, and 32 pairs of SFT*ymdd files.

PLTLIMITS contains 6 versions of the file which controls the plot limits for the code PLOTCP (see below).

R-FILES contains the 45 files output by REVERT in the processing mode, and contain the final result of this effort, the temperature corrected data.

REVREC contains the BCON terminal dialog listings for all BCON/RVCONTROL runs. The file names are RVRECmddS, where mdd is the date of the run, and S is the sequence letter of runs made that day.

RREC contains the REVERT diagnostic listings produced during processing of each of the R-files. The file names are RECnnn, where nnn is the last three digits of the B-file name.

RVRTLST contains 22 files named LISTyymmdd, which are listings in the Livermore format of the HPDB-files produced from the 22 "dump" tapes; nine files named RCnsALT, which are listings of the ALTER runs; and nine files named LISTnns, which are the results of the ALTER runs.

RVTINT contains 16 versions of ITEMNAME file, and 24 versions of ALTER file. The ITEMNAME files have names beginning with IN, while the ALTER files have names beginning with RC.

S-FILES, S-FILES2 contain the first and last versions of the S-files, 124 files in all.

X-FILES contains 65 files which are the output of SCAN, and list the number of records per day for selected S-files (see Section 3.0).

6.1.2 Plotting and Data Listing (PLOTCP, PLOTR, BTOA5)

The S-files are ASCII and can be listed and edited with LTSS Utility Routine TRIx, or almost any other text editor. The search functions in such codes can be very valuable if one is trying to find out which instruments are not functioning at a particular time, or what the first value of a particular instrument is. The answers to such questions were useful in deciding what data to enter into the HPDB-file.

The code BTOA was written to convert binary B-files and R-files to ASCII so they could be similarly searched, and a number of options were included. The most recent version of the code is BTOA6, and the source listing is included in Appendix A. There are three output options: S-file format with HP-converted data as used with BREAD, S-file format with HP data replaced with REVERT temperature corrected data, or, an expanded format, (1X,A4,1X,R6,F15.5,3E15.6), containing LCN, license, time, HP data, raw data, and REVERT data, in that order.

If the latter option is chosen, the user is asked for selection criteria to apply to the data:

"TYPE COUNT,OFFSET,START,STOP,A(FOR ABSOLUTE TIME)"

Count is the maximum number of lines to list, starting OFFSET lines after each change in license, rejecting lines which do not fall between times START and STOP. If the A is entered after the STOP time (comma delimited), the absolute value of the time is used (the DAS set times negative if it was unable to convert the data). A negative value of OFFSET gives the requested number of lines before the license change. An additional selection criteria is then requested:

"-9999. OR GOOD DATA? (B=BOTH, - = -9999., G=GOOD ONLY)"

A minus sign ("-") selects only lines which have a REVERT data value of -9999., indicating REVERT could not process the data. A "G" selects only data lines REVERT was able to process correctly, and a "B" selects both types. The name of the output file is AOUT.

BTOAG was invaluable in scanning the huge binary files, reducing the amount of data to an amount a human user could assimilate. It was used for several reasons, to examine in detail data which looked strange on plots, to produce a "snapshot" of data from many channels over a limited time (usually one day) to compare with computational modeling results, and to find the first and last occurrences of each license in a given file.

PLOTOMP was the major diagnostic plotting code (internal memorandum SFT 82-169, Hage to Distribution, November 9, 1982). It was run automatically by the BCON control process RVCONTROL on every R-file. Both FR80 (fiche) and NIPS (hardcopy) plots are produced in four formats: raw data, HP data, REVERT data, and both HP and REVERT data overlain on the same plot. There is no choice of license, all in the file are plotted automatically. The time axis is either set by the minimum and maximum values in the data and is potentially different for each license, or is set by the user and is the same for all licenses (the latter was the usual case).

The vertical axis is either chosen by PLOTCMP based on the data range for each plot, or set by values in a file of plot limits. The file was called PLTLIMITS, and contains four types of scaling information for each instrument. First were "nice" scales to be used for converted data, then the BREAD data screening limits for raw data which were as broad as the physical limits of the instrument, then the limits used at NTS to trigger alarms and set fairly tightly about the converted data, and finally, the X limits, the most commonly used, and which were set to just fit the data over the entire time frame of the test. Another difference between the first and last limits set is that, for the first set, if a license is not in the list, it is not plotted. For the "X" set, if the limits are not defined in the file they default to the data limits.

RVCONTROL used PLOTCMP in the "compare" mode where both the HP and REVERT values were overlain. By comparing the two curves, anomalies could be quickly spotted. There were many possible reasons for such anomalies. These were systematically rooted out, and, if the problem were with REVERT or its database, corrected.

PLOTR generated similar plots, but deals with one license at a time, and needs no PLTLIMITS file. It plots either from S-files, or binary files, and will accumulate the data over the time range desired from several such files. When plotting from S-files the filenames are given on the terminal. If plotting is from binary files, PLOTR wants a disk file named LISTFILES with the names of the binary files. In either case, the list of names must be in chronological order. PLOTR is described in more detail in internal memorandum DM 80-71, Harben to Distribution, December 4, 1980.

6.2 L-file System (UFO, UFRO, VFO, WFO)

To plot one license over the entire three-year life of the test using PLOTR would require searching through all 45 binary files, or worse, 124 S-files. The plan was to condense the data by a factor of ten or so into 4 or 5 binary files, and a code was written to do this, on a trial basis, in May 1982. At that time, however, we were still struggling to superimpose sufficient order on the mass of data so the corrections could be done

reliably. There was also the desire to plot pass 1 and 2 devices, already converted reliably by the DAS at NTS. An independent effort was thus mounted to rearrange the data from the (at the time) 47 files of 400-700 licenses each, to 793 files of one license each. It was impossible to maintain a file index that large on the CDC 7600's during normal time-sharing periods, so the first transfer (S-files 000-063) was made over the 1982 Christmas-New Year holiday. S-files 064 through 070 were transferred on 21 May 1983, and S-files 071 through 075 in November, 1983. Three codes were involved (UFO, VFO, and WFO), written by D. N. Montan, plus the design, by Montan and L. B. Ballou, of a dual directory structure in which the files could be stored.

6.2.1 Transposition and Archiving

The BREAD output format normally occupied five 60-bit words, unless the data were flagged as anomalous. UFO (Uniformly Formatted Output) read the BREAD output files with a formatted read, and wrote the data out, ignoring the flags. This ensured that each line used exactly five words so later codes could buffer the data as binary reads instead of formatted reads, improving speed of execution. UFO also produced a statistics file, called a "TF" file, along with the data file now called a "UF" file. The "TF" files are summarized in "FLIT" files (File Length Index Table).

The next step was to read the "UF" files in turn and append them, license by license, into one of the existing files, or if the license was new, create a new file for it. This was accomplished by VFO (Voluminous File Output).

After discovering several hundred records erroneously interleaved with data from another license, a third code was written, WFO (We Find Out) which was used to scan all the output license files (L-files) to check for out-of-order licenses and/or times and, optionally, sort them.

As more S-files were added to the system, this process was repeated until all 124 S-files were transposed into 969 L-files. They were stored in 36 subdirectories under "TAKE" directory .040400.

After the REVERT process was finished, UFO was modified to read the R-files. This code was named UFR0, and was compiled under a different compiler and utility routine library than UFO. This caused an unexpected problem. If the last floating point value on the line was exactly zero, the new system would place a left adjusted "0." in the field, instead of the right adjusted ".0E+00" supplied by the previous system. In this case, the line would fit in only four words. UFR0 corrects the problem by setting trailing zero values to E-99. The transposition of R-files was accomplished soon after the final REVERT runs in May 1985, storing the new L-files in a duplicate directory structure under "TAKE" directory .685350 as in Table 6.2.1-1.

6.2.2 L-file Data Plotting and Listing (KURV)

Since the L-files are ASCII, and in fact in the same format as the S-files, any number of codes can be used to list and plot the data, including PLOTR. One code, KURVSFT, was expressly modified for use on SFT-C data, and, in modified form as KURVWES, was used to produce the data plots of Appendix D. KURVSFT produced a time axis in years since the spent fuel was removed from the reactor, or "years out of core" (YODC). KURVWES, on the other hand used a time axis measured in days since 1 January, 1980, or, equivalently, JD minus 44240. Neither code is formally documented, but a HELP listing is reproduced as Fig. 6.2.2-1 to help illustrate its capabilities.

Table 6.2.1-1. REVERTed L-file storage directories and their contents.

CDX	26 files, including all the CDE's, COG's, and CDT's.
CEHxx	17 subdirectories, each with 18 files (except CEH02, which has 19), all SCT'S, SLT's, and SPT's, for canister hole xx=1, 17.
CWE/THE	45 files, all CWE's and THE's, and their excitation CCE's.
CWTEMP	34 files, all CWT's and THT's, the 4-wire temperature readings for the CWE's and THE's.
FMS01-07	28 files, all the FMS's and their FMT's.
GAE/GDE	20 files, all the A and D group RX's, their excitations, and temperature references.
GBE01-03	44 files, GBE01* through GBE03*, with their excitations, and temperature references.
GBE04-06	42 files, GBE04* through GBE06*, with their excitations, and temperature references.
GCE01-03	43 files, GCE01* through GCE03*, with their excitations, and temperature references.
GCE04-06	53 files, GCE04* through GCE06*, with their excitations, and temperature references.
MBI01-03	36 files, MBI01* through MBI03*, with their excitations, and temperature references.
MBI04-06	36 files, MBI04* through MBI06*, with their excitations, and temperature references.
MBI08-10	37 files, MBI08* through MBI10*, with their excitations, and temperature references.
MBI11-13	36 files, MBI11* through MBI13*, with their excitations, and temperature references.
MISC-T/C	48 files, NET15*, NET17*, NHH04*, NHT's, SET16*, SET18*, SHT's, TRT's.
RTD/SSR	32 files, all RTD's and SSR's.
THMSTR	19 files, all BWT's and CWT's of device type PN.
VENT	19 files, various air temperatures and dew point meters, (AFM's, ATM's, CAT's, DPM's, NAT's, RAT's, and SAT's.)
VWSM	49 files, all CSG's and NSG's, with their SGT's.
WATT	15 files, all Watt meters (CHW's, CLW's, NHH's, NLW's, SHW's, SLW's).

Figure 6.2.2-1. Example of KURV help pack.

THE KOMPELETE KURV HELP PACKAGE (VERSION 0 38 DEC 1982)

KURV USES UKLIB FROM THE UKDDB8 GRAPHICS SYSTEM(UCID-38146)
 OUTPUT FILES REMAIN ON DISK AND MAY BE PROCESSED WITH THE
 MJB LIB UTILITY ROUTINES UKTV, UKRJ, UXFR, UKEDIT, UXNIPS
 FURTHER 'HELP' PACKAGES ARE AVAILABLE AT ANY INPUT REQUEST
 FOR QUESTIONS ABOUT: KURV SEE D N MONTAN X23941
 UKDDB8 SYSTEM SEE MARK BLAIR X24266

INPUT FILE: NAME OF DATA FILE WITH X IN COL 1-18, Y 11-28
 DEFAULT: PREVIOUS FILE (TYPE END TO END KURV)
 FILE NAMES MUST BEGIN W/ A LETTER AND HAVE 2-7 CHARACTERS
 A SINGLE CHARACTER MAY INVOKE ONE OF THE FOLLOWING OPTIONS
 A BREAK FOR ARTESIANS
 B BALLOU'S TID PROOF (T) PACKAGE
 D RETRY OVERSIZE FILE BY SKIPPING LINES
 E ASK FOR NEW FORMAT
 G ASK FOR GRID MODIFICATION PARAMETERS
 H HIGH INTENSITY
 K GO TO PROD. MODE, FIND & LIST EXTREMA, NO PLOTS
 L LOW INTENSITY (DEFAULT)
 M MODIFIED NUMBERING ON GRID AXES
 N NORMAL NUMBERING ON GRID AXES
 O ASK FOR NUMBER OF STRIKES
 P GO TO PRODUCTION MODE
 S ASK FOR PLOTTING SYMBOL
 T ASK FOR TICK SIZE
 U X COMES BEFORE Y IN INPUT FILE, ASK FOR NEW FORMAT
 V Y COMES BEFORE X IN INPUT FILE, ASK FOR NEW FORMAT
 X X COMES BEFORE Y IN INPUT FILE
 Y Y COMES BEFORE X IN INPUT FILE
 / ACCEPT 1 LETTER INPUT FILE NAMES
 \$ RETURN TO 1 CHARACTER OPTION MODE

LIMITS: PLOTTING LIMITS XMIN,XMAX,YMIN,YMAX,NGRID,NLABEL
 DEFAULT: PREVIOUS VALUE(S) (INITIALLY 0,1800,0,1800,9,1)
 IF USER SETS XMIN = XMAX AND/OR YMIN = YMAX KURV WILL FIND
 THE APPROPRIATE EXTREMA, REPORT THEM AND AWAIT USER ACTION
 NGRID IS AN INTEGER (1-15) USED TO CONTROL MAPPING
 NO GRID 1 LIN-LIN 2 LOG-LOG 3 LIN-LOG 4 LOG-LIN
 FULL GRID 5 " 6 " 7 " 8 "
 PARTIAL GRID 9 " 10 " 11 " 12 "
 POLAR COORD. 13 NO AXES 14 W/ AXES 15 + AT 0.0
 -NGRID ELIMINATES FILENAME FROM THE PLOT
 NLABEL = 0 ELIMINATES LABEL REQUESTS

X & Y TICKS: AXIS MAJOR TICK, MAJOR/MINOR RATIO, OFFSET
 DEFAULT: PREVIOUS VALUE(S) (INITIALLY KURV SUPPLYS THEM)

Figure 6.2.2-1. Continued.

SIZE: CRT PLANE GRID POSITION XMI,XMA,YMI,YMA,NPLOT,NCOLOR
 DEFAULT: PREVIOUS VALUE(S) (INITIALLY .1,.95,.35,.95,2,1)
 NPLOT DETERMINES THE TYPE OF PLOTTING
 1 = POINTS, 2 = POINTS W/ LINE, 3 = + , 4 = + W/ LINE.
 5 = DASH, 6 = DASH DOT, 7 = DASH DOT DOT, ETC. UP TO 20
 FOR NPLOT > 20, NPLOT.MOD.10 CONTROLS PLOTTING & NPLOT/10
 DETERMINES MINIMUM SYMBOL (+) SPACING (1024 X 1024 RASTER)
 -NPLOT PREVENTS FRAME ADVANCE AFTER PLOTTING
 NCOLOR = 0 ELIMINATES COLOR REQUESTS

COLORS: NUMBERS FOR COLOR OF GRID,POINTS,+,FILE,LABELS,LOGO
 DEFAULT: PREVIOUS VALUE(S) (INITIALLY 14,3,10,8,18,16)
 FOR +COLOR > 20, +COLOR.MOD.20 CONTROLS COLOR & +COLOR/20
 DETERMINES PLOTTING SYMBOL (+) SIZE (0 MINIATURE 3 LARGE)
 -LOGO GIVES HALF DENSITY LOGO LOGO = 0 ELIMINATES LOGO
 COLOR NUMBERS ARE:

1 WHITE	2 RED	3 VERMILION	4 ORANGE
5 APRICOT	6 YELLOW	7 BANANA	8 GREEN
9 AQUA	10 TORQUOISE	11 SKY-BLUE	12 CYAN
13 BLUE	14 INDIGO	15 PURPLE	16 FUSCHIA
17 BURGUNDY	18 CHERRY-RED	19 TRUE-WHITE	

LABELS: TYPE Y OR YES FOR PROMPTS TO ENTER X, Y, & T LABELS
 TYPE RULER TO GET A RULER ON THE PLOT, YES FOR TTY RULER
 DEFAULT: NO LABELS (TYPE S FOR PREVIOUS LABELS)
 CHARACTER SIZE: SMALL (84 PER LINE)
 STARTING POSITION: 5 CHARACTERS BELOW & LEFT OF XMI, YMI
)2 4 6 8(1)2 4 6 8(2)2 4 6 8(3)2 4 6 8(4)2 4 6 8(5)2 4 6 8(6)2 4

X LABEL: 80 CHARACTER (MAX) X-AXIS LABEL
 DEFAULT: NO LABEL (TYPE S FOR PREVIOUS LABEL)

Y LABEL: 80 CHARACTER (MAX) Y-AXIS LABEL
 DEFAULT: NO LABEL (TYPE S FOR PREVIOUS LABEL)

T LABEL: 80 CHARACTER (MAX) ABOVE GRID LABEL
 DEFAULT: NO LABEL (TYPE S FOR PREVIOUS LABEL)

FORMAT: FORTRAN FORMAT TO BE USED TO READ INPUT FILE
 DEFAULT: PREVIOUS FORMAT (INITIALLY F10.0, F10.0)

PLOTTING SYMBOL: A SINGLE CHARACTER USED WITH NPLOT 3 OR 4
 DEFAULT: PREVIOUS SYMBOL (INITIALLY +)

PRODUCTION FILE: NAME OF FILE WITH LIST OF INPUT FILES
 AND (OPTIONALLY) PLOTTING PARAMETERS
 DEFAULT: INDIVIDUAL INPUT (TYPE HELP FOR MORE HELP)
 (TYPE END TO END KURV)

Figure 6.2.2-1. Continued.

PRODUCTION FILE OPTIONS:

COL	FORM	NAME	SYMBOL	USE
1-7	A	IFILE		NAME OF DATA FILE TO BE PLOTTED
8-10	A	JFILE		INFO TO GO IN LOWER RIGHT OF PLOT
11-20	A	KFILE		INFO TO GO IN UPPER RIGHT OF PLOT
21	A	MA		NOT CURRENTLY USED
22	A	MB		NOT CURRENTLY USED
23	A	MC		IF NONBLANK USED AS PLOTTING SYMBOL
24	A	MD	D	RETRY LARGE FILES BY SKIPPING LINES
25	A	ME	D	PLOT ONLY POINTS WITHIN THE GRID
			E	PLOT ALL POINTS
			U	X - Y READ NEXT CARD FOR FORMAT
			V	Y - X READ NEXT CARD FOR FORMAT
			X	X BEFORE Y IN INPUT FILE
			Y	Y BEFORE X IN INPUT FILE
26	A	MF	A	ASK USER FOR LIMITS
			R	FIND & USE X-LIMITS
			S	FIND & USE Y-LIMITS
			T	FIND & USE ALL LIMITS
			U	FIND & USE X-LIMITS > XMIN, < XMAX
			V	FIND & USE Y-LIMITS > YMIN, < YMAX
			W	FIND & USE ALL LIMITS > < AS ABOVE
			X	USE GIVEN X-LIMITS
			Y	USE GIVEN Y-LIMITS
			Z	USE GIVEN X & Y LIMITS
27	A	MG	A	ASK USER FOR SIZE
			R	READ NEXT CARD FOR SIZE (6F10.0)
28	A	MH	A	ASK USER FOR COLORS
			L	LOGO = NC (SEE BELOW)
			R	READ NEXT CARD FOR COLORS (6F10.0)
29	A	MI	A	ASK USER FOR LABELS
			N	NO LABELS
			R	READ NEXT 3 CARDS FOR X Y T LABELS
			S	USE PREVIOUS LABELS
30	A	MJ	L	PRODUCTION FILE NAME ON PLOT
31-33	I	NA		IF NON-ZERO NGRID = NA
34-36	I	NB		IF NON-ZERO NPLOT = NB
37-39	I	NC		IF YH IS L LOGO = NC
40	I	ND		PRODUCTION COUNTER INCREMENTOR
41-50	F	XMIN		USED WITH -MF- OPTIONS U W X Z
51-60	F	XMAX		USED WITH -MF- OPTIONS U W X Z
61-70	F	YMIN		USED WITH -MF- OPTIONS V W Y Z
71-80	F	YMAX		USED WITH -MF- OPTIONS V W Y Z

TOOLS OF THE TRADE

THERMODYNAMICS
 THAUMATURGY
 THEOLOGY
 FORCE
 73

WE BREAK FOR ARTESIANS
 10-3.2 GOOD BUDDY

IF YOU CAN KEEP YOUR HEAD IN ALL THIS CONFUSION
 YOU JUST DON'T UNDERSTAND THE SITUATION DNM X 2-3941

7.0 DATA PRESENTATION AND CONCLUSIONS

7.1 Data Presentation

The data are presented on a set of 17 fiche as Appendix D. There is one trace per license, covering the full time range of the test, although there may be more than one trace (or license) on a given frame. The time scale is days since January 1, 1980 to allow smaller numbers as labels. To convert to the Julian Day value reported elsewhere in this report, simply add 44240. Table 7-1 is provided to help convert JD values to calendar dates, and gives the JD value for the 1st, 10th, and 20th of each month for the years 1980 through 1984. The day of the week of the 1st is also given, along with the day of the year.

The plots are grouped according to function and the groups are labeled with large labels, readable on the fiche with the naked eye, to facilitate finding any desired group. The labels are similar to the subdirectory names given in Section 6.2.1, but are in a functional rather than alphabetical order. The functional order is thermal sources first, sinks second, responses third, and general/diagnostics fourth, as shown in Table 7-1.

The points are plotted without connecting lines, so any data which go off screen are simply not seen. Values of -9999., the "unable to convert" flag, are not plotted.

7.2 Conclusions

Throughout the Technical Measurements Data Management effort, we attempted to build a system which was robust and versatile. Robust so that unexpected forms of data would not "crash the system" or generate difficult to trace errors, and versatile so the system could easily adapt to new (though valid) data forms. From the scanning of the data done so far, it appears we succeeded. We have been able to maintain or superimpose a consistent structure on the data, so necessary for computer processing, through a test history with many instrument failures and replacements.

There are many ways to present such a large mass of data. We have chosen fiche plots of each instrument over the entire time span of the test. We hope that this allows an easy first look at the entire data set with sufficient precision to, (A) plan precisely what view of the data would best serve the readers' interest, and (B) pique interest in using the data as is or in requesting the data in another form. The data are presented here without analysis (analyses are presented in other project reports), but with as much background information as could reasonably be included, so the reader could make his/her own conclusions. We encourage scrutiny, and requests for more information or other forms of the data. Please contact the LLNL Nuclear Waste Management Project Office or the author with such requests.

Table 7-1. Organization of Appendix D.

<u>Group</u>	<u>Fiche#</u>	<u>Frames</u>	<u>Description</u>
CEH	1,2	51	Close in TC's in the 17 CEH holes, 3 frames per hole, showing the top, middle, and lower sets of TC's. Each set is 3 pairs, SPT's, SLT's, and SCT's, in order of increasing temperature.
WATT	2	15	Watt meter traces for the 6-CHW00x's, CLW001, 3-NHW00x's, NLW001, 3-SHW00x's, and SLW001,
VENT	2	17	Air Temperatures and Dew Point meters SAT003, 3-AFMxxx's, ATM006, CAT001, 4-DMPxxx's, NAT001, NAT002, SAT001, NAT003, RAT001, and SAT002.
CDX	3	26	Canister hole deformation gages, their excitation supplies, and reference temperatures. 6-CDE0xx's, 14-CDG0xx's, and 6-CDT0xx's
CWETHE	3,4	43	Convergence wire extensometers and their excitation supplies. 8-CCExxx's, 33-CWExxx's, 2-THE00x's. (CWE121 and CWE122 were not plotted due to insufficient data.)
CWTEMP	4,5	31	Four-wire temperature readings for the wire extensometers. 31-CWTxxx's.
FMS0107	5	28	The fracture monitors and their reference temperatures. 21-FMS0xx's, 7-FMT0x0's.
GAEGDE	6	20	A and D group rod extensometers, their excitations, and reference temperatures. 5-AET01x's, 5-DET01x's, 5-GAE01x's, and 5-GDE01x's.
GBE0103	6,7	44	GBEx1x, GBEx2x, and GBEx3x rod extensometers, their excitations, and reference temperatures. 5-BET01x's, 5-BET02x's, 5-BET03x's, 10-GBEx1x's, 10-GBEx2x's, 9-GBEx3x's.
GBE0406	7,8	42	GBEx4x, GBEx5x, and GBEx6x rod extensometers, their excitations, and reference temperatures. 5-BET04x's, 5-BET05x's, 5-BET05x's, 9-GBEx4x's, 9-GBEx5x's, 9-GBEx6x's.
GCE0103	8,9	43	GCEx1x, GCEx2x, and GCEx3x rod extensometers, their excitations, and reference temperatures. 5-CET01x's, 4-CET02x's, 5-CET03x's, 10-GCEx1x's, 10-GCEx2x's, 9-GCEx3x's.
GCE0406	9,10	52	GCEx4x, GCEx5x, and GCEx6x rod extensometers, their excitations, and reference temperatures. 5-CET04x's, 5-CET05x's, 5-CET06x's, 13-GCEx4x's, 12-GCEx5x's, 12-GCEx6x's.

Table 7-1. Continued.

Group	Fiche#	Frames	Description
MBI0103	10,11	36	MBI01x, MBI02x, and MBI03x rod extensometers, their excitations, and reference temperatures. 4-MBI01x's, 7-MBI02x's, 7-MBI03x's, 4-NET01x's, 7-NET02x's, 7-NET03x's.
MBI0406	11,12	36	MBI04x, MBI05x, and MBI06x rod extensometers, their excitations, and reference temperatures. 4-MBI04x's, 7-MBI05x's, 7-MBI06x's, 4-SET04x's, 7-SET05x's, 7-SET06x's.
MBI0810	12,13	36	MBI08x, MBI09x, and MBI010x rod extensometers, their excitations, and reference temperatures. 4-MBI08x's, 7-MBI09x's, 7-MBI010x's, 4-NET08x's, 7-NET09x's, 7-NET010x's.
MBI1113	13,14	36	MBI11x, MBI12x, and MBI13x rod extensometers, their excitations, and reference temperatures. 4-MBI11x's, 7-MBI12x's, 7-MBI13x's, 4-SET11x's, 7-SET12x's, 7-SET13x's.
VWSM	14,15	48	Vibrating wire stressmeters, and their reference temperatures. 6-CSGx1x's, 6-CSGx2x's, 12-NSGx3x's, 12-NSGx4x's, 2-SGTx1x's, 2-SGTx2x's, 4-SGTx3x's, 4-SGTx4x's.
MISCTC	15,16	48	Miscellaneous TC's. 4-NET15x's, 5-NETx7x's, 4-NHH04x's, 4-NHT01x's, 4-NHT02x's, 4-NHT03x's, 4-NHT04x's, 4-NHT05x's, 4-SET16x's, 4-SET18x's, 4-SHT01x's, 3-TRT01x's.
RTDSSR	16,17	30	RTD's and SSR's. 22-RTDxxx's, 8-SSR00x's.
THMSTR	17	19	BWT's and CWT's of type PN (see Section 5.1.4). 10 BWT0xx's, 9-CWT00x's.

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D. N. Montan wrote the codes used in transmuting the S-files and later, the R-files, to L-files. He and L. B. Ballou spent many hours (mostly nights, weekends, or holidays), developing the directory structure, testing the codes' interaction with that structure, and, finally, running the transmutations. Montan also modified an existing plotting code, KURV, expressly to handle SFT-C data, and used the result, KURVSFT, to produce the plots presented in Appendix D.

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