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Heated Axisymmetric Pillar Test (Room H): In Situ Data Report (February 1985 - April 1987)

Waste Isolation Pilot Plant (WIPP) Thermal/Structural Interactions Program

Darrell E. Munson, Robert L. Jones, David L. Hoag, John R. Ball

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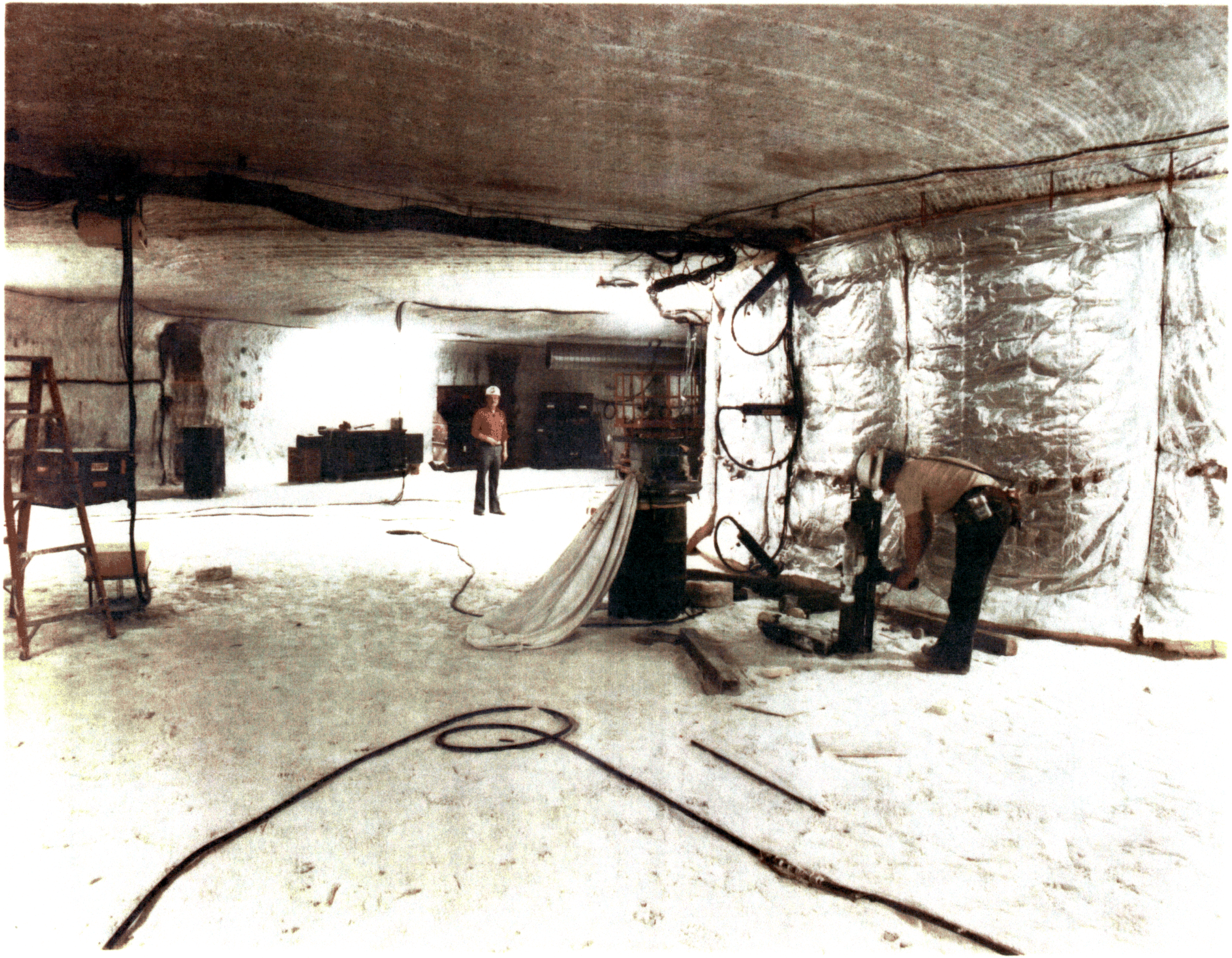

Flyleaf. View of Room H During Construction

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HEATED AXISYMMETRIC PILLAR TEST (ROOM H): IN SITU DATA REPORT (FEBRUARY 1985 - APRIL 1987)

WASTE ISOLATION PILOT PLANT (WIPP) THERMAL/STRUCTURAL INTERACTIONS PROGRAM

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ABSTRACT

Data are presented from the Heated Axisymmetric Pillar Test, a very large-scale, in situ test fielded underground at the Waste Isolation Pilot Plant (WIPP). These data include selected fielding information, test configuration, instrumentation activities, and comprehensive results from a large number of gages. The results give measured data from room closure gages, extensometers, stress meters, thermocouples, flux meters, and power gages emplaced in the test. The test began in February 1985 and continues to the present. Data in this report cover the period from February 1985 to April 1987, and will be updated as necessary in future reports.

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1 INTRODUCTION

In 1981 the Waste Isolation Pilot Plant (WIPP) Project, under the direction of the US Department of Energy (DOE), began construction of a facility in southeastern New Mexico to develop the technology for disposing of radioactive waste from the defense programs. This facility may eventually become a repository for defense Transuranic (TRU) wastes, provided that the facility is demonstrated to be acceptable. Although the complete facility includes both surface and underground construction, the Experimental Programs Division at Sandia National Laboratories (SNL) is primarily concerned with development of the underground portion of the facility; we focus on that portion of the facility in this report. Underground construction consisted of three phases: (1) the Site and Preliminary Design Validation phase for the construction of two shafts, shaft stations, a limited entry system, the Transuranic Test Panel, and an exploratory drift (South Drift) to the southern extremity of the facility; (2) the Experimental Area construction phase for the construction and fielding of several large Research and Development (R&D) test rooms and the expansion of the shaft system; and (3) the TRU Waste Storage Area construction phase for the construction and operation of a retrieval demonstration panel, and, if acceptable, eventually for the storage of radioactive contact-handled (CH) and remote-handled (RH) waste. The first two construction phases are complete, and data are being acquired for facility design validation and for technology development. Construction of the third phase has begun, in preparation for receipt of TRU waste. Also, and very importantly, in a fully operational sense, the Research and Development activities associated with Technology Development for both TRU and Defense High Level Waste (DHLW) continue within the Experimental Area. The research currently in progress and the research planned within the Experimental Area is providing and will continue to provide in situ data of exceptional quantity and quality.

The experimental activities conducted in the underground facility are the responsibility of Sandia National Laboratories. These in situ activities consist of several very large-scale tests and many small-scale experiments to address important technology issues through the Thermal/Structural Interactions (TSI), Waste Package Performance (WPP), and Plugging and Sealing (PSP) Programs. The technology issues address (1) the disposal of TRU CH and RH wastes, which is directly relevant to the proposed disposal of TRU wastes at the WIPP, and (2) the disposal of DHLW. DHLW is currently slated for disposal in a commercial repository. The WIPP in situ testing addresses specifically the disposal of wastes generated from current and past defense programs. These tests, initially defined in a detailed planning document [1], were carried forward by individual test plans defining the implementation and fielding activities for each specific test.

This report is specific to the TSI in situ tests of the Experimental Area. Within the TSI program are six major tests which involve four rooms or room complexes: (1) the 18-W/m^2 Mockup for Defense High-Level Waste (DHLW) in Rooms A1, A2, and A3; (2) the Overtest for Simulated Defense High-Level Waste (DHLW) in Room B; (3) the Geomechanical Evaluation Test in Room G; (4) the Heated Axisymmetric Pillar Test in Room H, and (5) the In Situ Stress Field (Hydrofrac) Test in Room G. The Clay Seam Shear Test (6), although planned, is not yet fielded. In situ data are also being obtained from Room D, an early excavation for facility ventilation. Several significant documents have discussed the planning, implementation, and fielding of these TSI in situ tests [2-4], and the reader is referred to the original documents for more detailed information.

This data report is one of a series intended to document the data obtained from the TSI in situ tests and to make these data available to potential users. The report specifically centers on the data acquired from the temporary and permanent gages of Room H from February 1985 to April 1987, and will be updated as necessary.

2 EXPERIMENT DESCRIPTION

As given in the test plan [5], the Heated Axisymmetric Pillar, Room H in situ test was established as an intermediate test for in situ confirmation of the constitutive response of salt. The design and fielding of the test conform almost exactly to a two-dimensional (2-D), axisymmetric geometry, which matches the normal constraints of 2-D, finite element, calculational problems. With respect to the underground facility, Room H is located in the Experimental Area, as shown in Figure 2.0.1. The room configuration and construction sequence are almost as requested in the test plan; however, these exact descriptions, and special features of the room introduced during and after construction, will appear in separate documents on construction [6] and instrumentation [7], in preparation. Further relevant information is contained in separate documents on the data acquisition system [8], now available, and on the overall WIPP In Situ Data Acquisition, Analysis, and Management (WISDAAM) System [9], in preparation. Some limited information from these documents is required for our purposes here. Consequently, in this section we briefly discuss the room configuration, mining, and special features of Room H as background for the experimental data described in this report.

2.1 Room Configuration

2.1.1 Physical: As shown in Figure 2.1.1, the Room H test is configured as a completely isolated, cylindrically shaped pillar 5.49 m (18 ft) in radius x 3.05 m (10 ft) high and centrally located in an annular drift 11 m (36 ft) wide x 3.05 m (10 ft) high. A typical "as-built" cross section determined at the room station of 270° is illustrated in Figure 2.1.2. Access to the room is through an entry 50 m

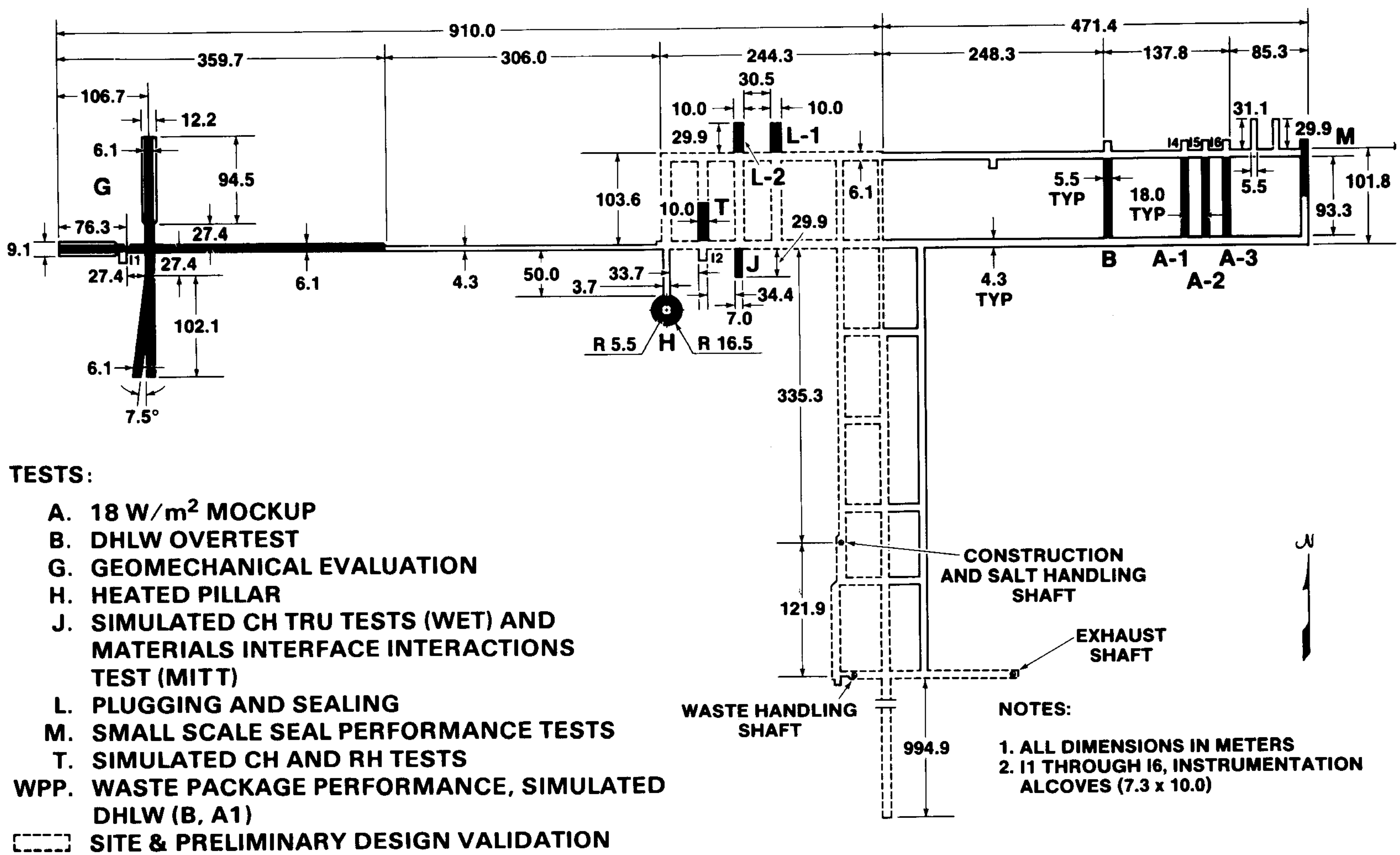

Figure 2.0.1. Plan View of the Underground Facility at the WIPP

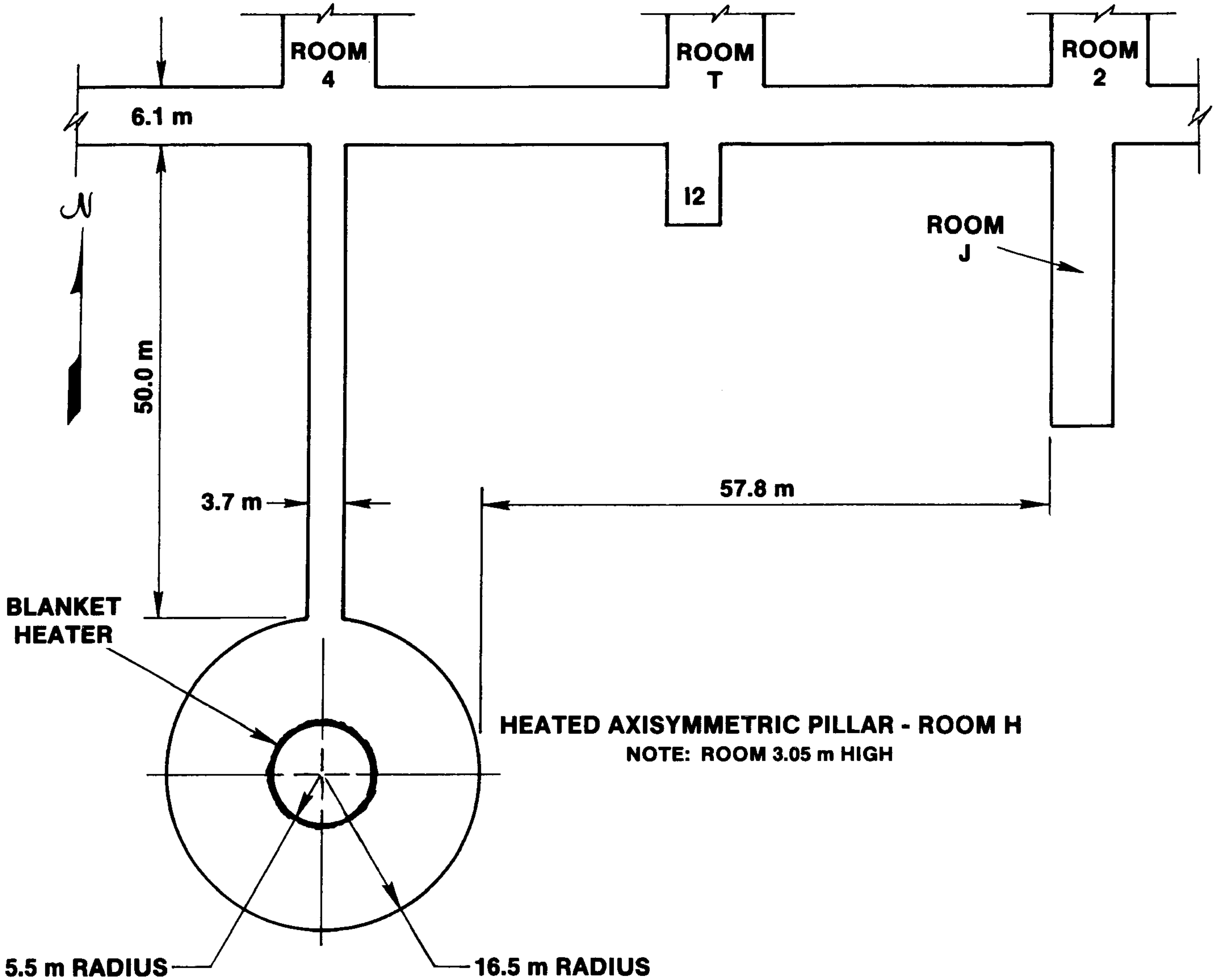

Figure 2.1.1. Plan View of the Axisymmetric Heated Pillar Test Room

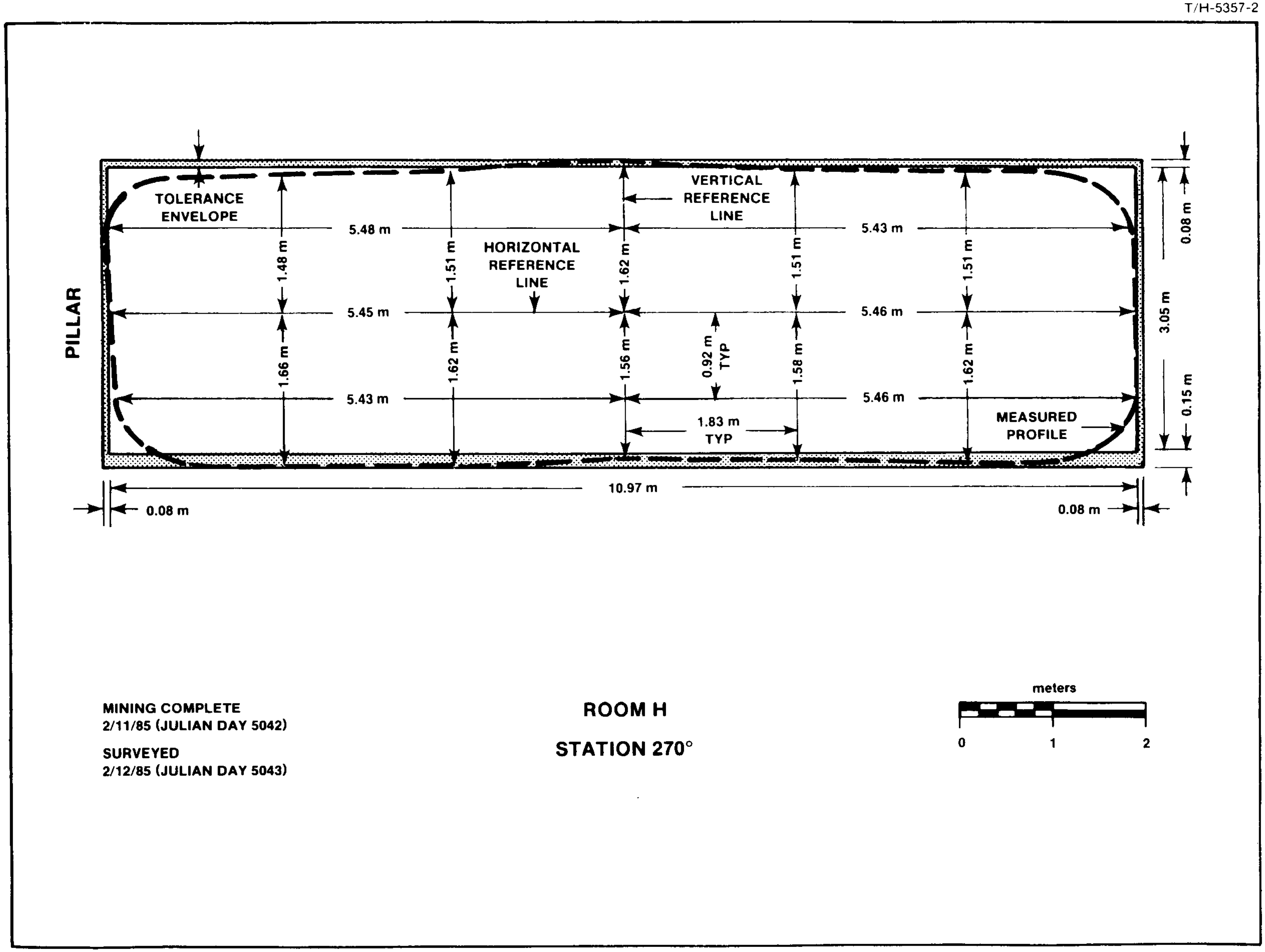

Figure 2.1.2. Typical "As-Built" Cross Section of Room H, 270° Station

(164 ft) long, 3.66 m (12 ft) wide, and 3.05 m (10 ft) high from the nearest subentry drift to the north of the room. This access drift is the only geometrical deviation from the two-dimensionality of the final room configuration. The rock mass in the pillar has a volume of about 288 m^3 (10,180 ft^3), with a surface area of about 105 m^2 (1,131 ft^2).

2.1.2 Gages: Instruments and gages in the room consist of (1) temporary manual vertical and horizontal closure stations installed in the entry and annular room during excavation; (2) permanent manual-reading floor-to-ceiling closure stations; (3) permanent remote-reading vertical floor-to-ceiling and horizontal pillar-to-rib closure stations; (4) permanent remote-reading extensometers emplaced in boreholes 15.2 m (50 ft) deep vertically into the ceiling and floor and horizontally into the ribs, emplaced in horizontal boreholes 5.5 m (18 ft) deep into the pillar, and emplaced in diagonal boreholes 15.2 m (50 ft) deep in the ribs and 7.77 m (25.5 ft) deep in the pillar; and (5) remote-reading stress meters emplaced in boreholes up to 10.36 m (34 ft) deep around the room; (6) remote-reading thermocouples; and (7) remote-reading flux meters and heater power gages. Permanent closure, extensometer, and stress meter gages were installed immediately after completion of room excavation and drilling of instrument boreholes; thermocouple, flux meter, and power gages were installed before heating of the room started. In this test, a unique set of temporary stress and horizontal extensometer gages was installed from the entry drift into the pillar region before the annular room was actually excavated to form the pillar. Most of these temporary gages (gages not mined-out or intentionally removed) eventually became permanent and a few are still actively producing data. Although they are not reported here, mining sequence gages were installed and manually read throughout the multipass excavation [10]. Similarly, the manually read inclinometer data collected from boreholes around the room are very complex and are not reported here, but may be the subject of a special report at a later date.

The gages described above can be classified according to type. Most of the gages were devoted to displacement measurements which, along with the temperature measurements, were considered to be the highest priority in the experiment. The gage types are:

(1) Closures: either (a) Sinco[1] tape extensometer, manually read, anchored-pin emplacements, or (b) Research, Inc. (R.I.), constant-torque-spring, motor-driven, linear-potentiometer, remotely read stainless-steel cable (wire) installations;

(2) Extensometers: either (a) Serata E-200 or E-300 (produced as a Sandia modification), constant-torque-spring, motor-driven, linear-potentiometer, multipoint (4, 5, or 6 anchors) remotely read stainless-steel cable (wire) units, or (b) Irad 4000 series (a Sandia modification), undriven, linear-potentiometer, multipoint (4 or 5 anchors) remotely read Invar rod units;

(3) Stress meters: either (a) Sandia Strain Gaged Stressmeter (SGS) remotely read, three gage arrays emplaced in a rosette pattern, or (b) US Bureau of Mines (BuMines) Cylindrical and Borehole Pressure Cells (CPC and BPC) in arrays of one CPC and two orthogonal BPC, with remote Kulite pressure transducers;

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[1]Discussions of the gages used in these experiments can be found in the instrumentation report [7]. A selection of a particular manufacturer does not necessarily constitute WIPP Project endorsement of that gage.

(4) Thermocouples: Chromel-Constantan, fully jacketed, multipoint (1, 3, 4, or 5 points) remotely read junctions, grouted into place;

(5) Heat Flux: RDF 20457-3 Microfoil Heat Flow, remotely read sensors; and

(6) Power: current-viewing resistor and voltmeter, remotely read gages.

Table 2.1.1 summarizes the as-built gages.

Each gage has a unique designation code. Gage designations (numbers) were configured to convey important information about the gages. The gage designation code is of 7 alpha-numeric characters, for example H_301-1, and contains several useful pieces of information. The first character is a letter representing the specific test room (H here). Next is a character field indicating a subtest within the room (_ here, because there are no subtests in Room H). The next 3 character fields indicate the type and unit designation of the gage. The gage type system is given by the first of the 3 numeric characters: 0xx is a special gage type, 1xx is a manual closure gage type, 2xx is a remote closure type gage, 3xx or 4xx is an extensometer type gage, 5xx or 6xx is a stress meter type gage, and 7xx to 9xx is a thermocouple type gage. Special gages added after completion of the test plan have a gage type system with an initial alpha character keyed to the type of gage. In Room H the flux meters (Fxx here) have this kind of designation. The xx are unique numbers representing the individual units. The sixth alpha-numeric character is the subunit designation. In Room H we encounter only one type of subunit (- here), which tells us that the gages of the subunit are all contained in the same

Table 2.1.1. Gage Summary for Room H.

19 HEATER SEGMENTS 6' X 10' X 6" 157 HEATER TAPES NOMINAL 70 W/TAPE	INSTRUMENT UNITS									DRILLING	
	6 GAGES / UNIT	5 GAGES / UNIT	4 GAGES / UNIT	3 GAGES / UNIT	2 GAGES / UNIT	1 GAGE / UNIT	0 GAGE / UNIT	TOTAL UNITS	TOTAL GAGES	NUMBER OF HOLES	METERS OF HOLE
EXTENSOMETER											
SERATA E - 200	1	10	-	-	-	-	-	11	56	11	164.2
SERATA E - 300	-	-	6	-	-	-	-	6	24	6	45.8
IRAD	-	6	2	-	-	-	-	8	38	8	102.6
CLOSURE											
MANUAL											
TEMPORARY	-	-	-	-	-	11	-	11	11	22	3.3
PERMANENT	-	-	-	-	-	8	-	8	8	16	2.4
MINING SEQUENCE	-	-	-	3	-	10	-	13	13	26	4.8
REMOTE											
R.I.	-	-	-	-	-	8	-	8	8	0	0
INCLINOMETER											
SINCO	-	-	-	-	-	-	10	10	0	10	112.5
STRESS METERS											
BUMINES	-	-	-	20	-	-	-	20	60	20	131.5
SGS	-	-	-	3	-	-	-	3	9	3	14.8
THERMOCOUPLES											
ROCK MASS	-	5	14	6	-	1	-	26	100	26	258.7
REFERENCE											
FIXED	-	-	-	-	1	-	-	1	2	2	61.4
FLUID LEVEL	-	-	-	-	-	-	1	1	0	0	0
POWER	-	-	-	-	-	10	-	10	10	0	0
FLUX	-	-	-	-	8	-	-	8	16	6	1.8
AIR TEMP	-	-	-	-	2	2	-	4	6	0	0
AIR VELOCITY	-	-	-	-	-	1	-	1	1	0	0
TOTAL	1	21	22	32	11	51	11	149	362	162	903.5

(Note: Data of the mining-sequence gages, fixed and fluid level reference gages, and air temperature and velocity gages are not included in this report).

borehole. Finally, the last alpha-numeric character is the specific gage of the unit. Gages of a unit or subunit may range from 0 to 9. Some units, closure units for example, have only 1 gage.

The location of each gage is specified exactly, within the construction tolerance limits, in terms of the room cylindrical coordinate system of R (radius), T (theta, an angle taken positive counterclockwise from the east base line), and Z (height) with the origin at the midheight of the pillar axis. In general, the gage location requires pairs of coordinates that specify the two end locations of the gage. For gages set into boreholes, the first coordinate set (X_1, T_1, Z_1) defines the collar and the second set (X_2, T_2, Z_2) defines the point at depth. For a single point gage, the sets are duplicates. Because of the peculiarities of excavation of the test rooms in a slightly dipping geology, two pairs of Z values are given. One pair of values is the location in terms of the origin of the test room coordinate system; and the other pair of values is in terms of the local midheight origin of a principal station, as discussed later (Section 2.3.1). Both coordinates systems can be found as a portion of the results presented for each gage. Gage or unit (a collection of associated gages) locations are shown in the plan views of Figures 2.1.3 and 2.1.4, and in the elevation views of Figures 2.1.5 through 2.1.10. All permanent and temporary gages, even those not specifically addressed here, are shown in these figures.

2.1.3 Heaters: The surface of the pillar is heated by resistive Brisco BFH 052-100 LSE heater tapes, 3.05 m (10 ft) long, each rated at 520 W at 240 V. The tapes are hung vertically down against the pillar and are evenly spaced on about 219.5 mm (8.64 in.) centers around the pillar surface. Figure 2.1.11 shows these tapes are grouped into 19 panels, 1.83m (6 ft) wide x 3.05 m (10 ft) high. Each of the first 18 panels contain 8 tapes, and the last panel contains 13 tapes. This gives a total of 157 heater tapes. Two panels were paired together, with the power to each pair controlled by a separate Variac; the remaining single panel has its own Variac. Originally, each panel was assigned a unit number; however, the final Variac arrangement dictated that only one unit number could be assigned to a Variac. Consequently, even numbered units were deleted. The power input is controlled to a nominal surface heat flux value of 135 W/m^2 (12.54 W/ft^2). As will be apparent from the data presented later, the actual power is within 2% of the nominal value. Insulation was provided by Manville R Series Microlite Fiberglas duct insulation 152.4 mm (6 in.) thick, 1.83 m (6 ft) wide, and 3.05 m (10 ft) high butt-jointed together, with a batt section 0.91 m (3 ft) wide and 3.05 m (10 ft) high of the same material over the joint. The aluminum reflective coating of the insulation blanket was placed away from the pillar surface.

An insulated door was placed across the room-entry drift flush with the room rib, using the same Microlite Fiberglas insulation.

2.2 Construction

For this report, construction activities are summarized in abbreviated form. Only activities relevant to the temporary and permanent manual gages and to the remote gages are noted. Procedures and data for the mining-sequence gages are not discussed. Construction activities are divided into mining, instrumentation, and operation. Full construction details are contained in a separate document [6].

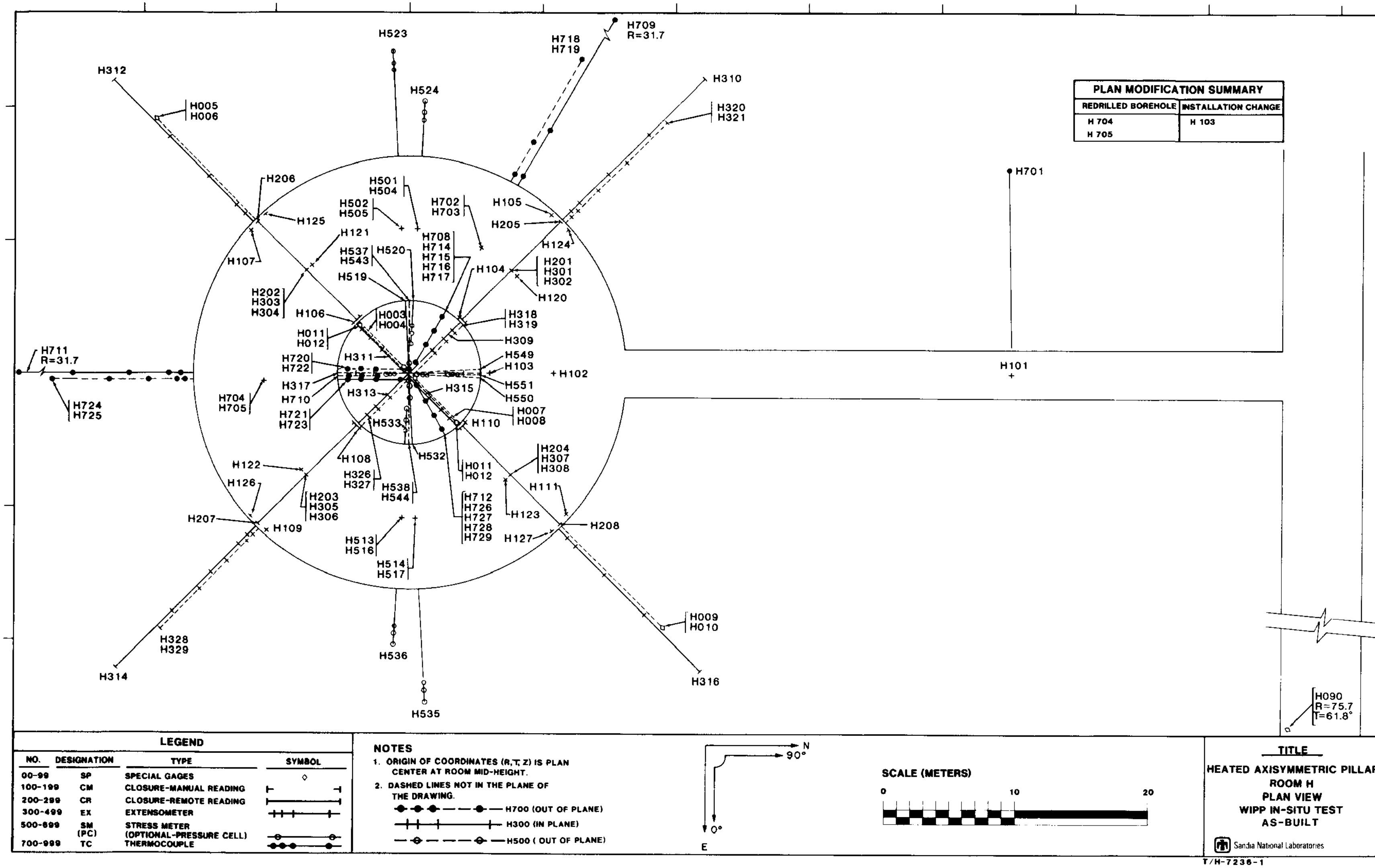

Figure 2.1.3. Plan Locations of the Instruments in Room H

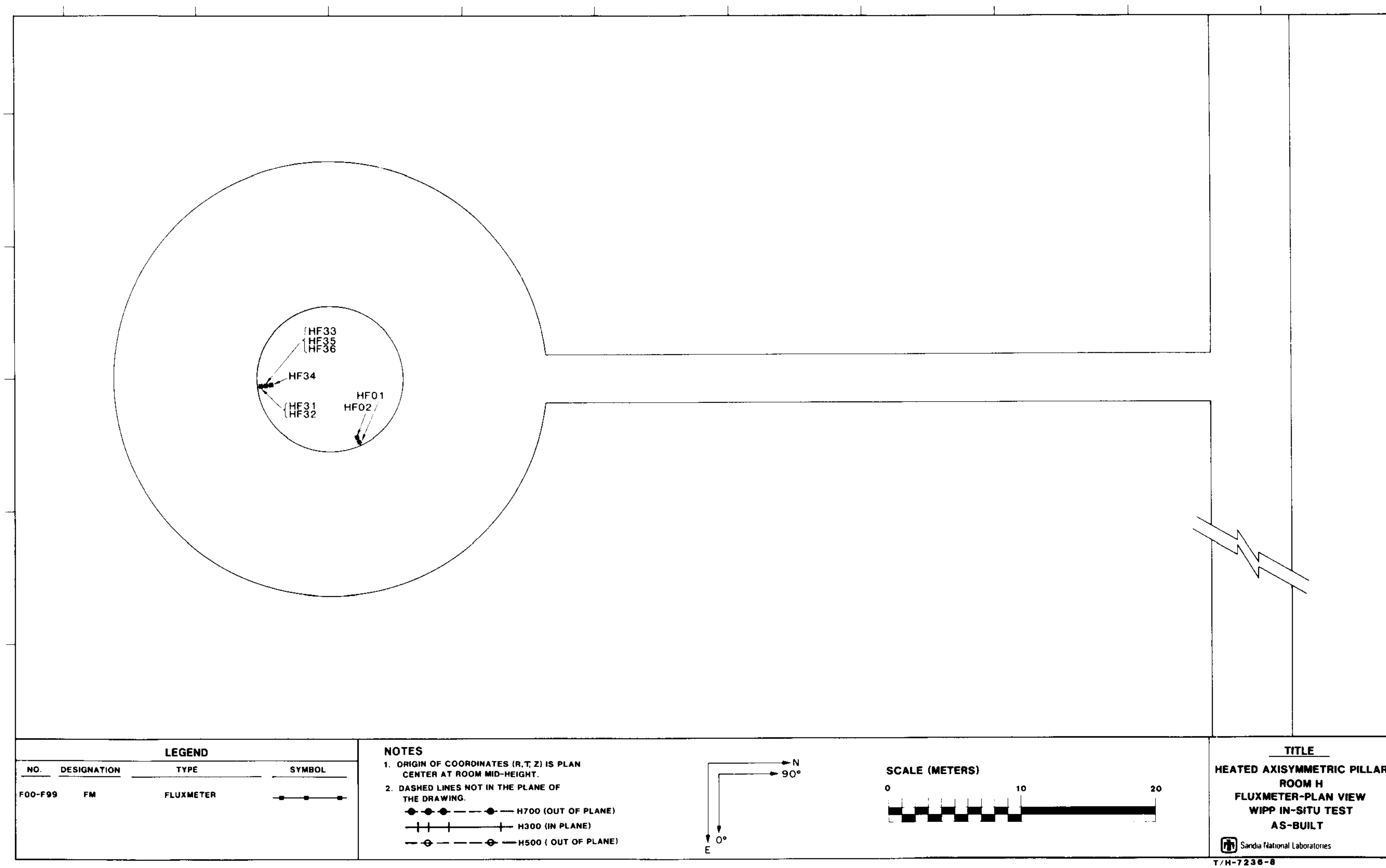

Figure 2.1.4. Plan Locations of Flux Meters in Room H

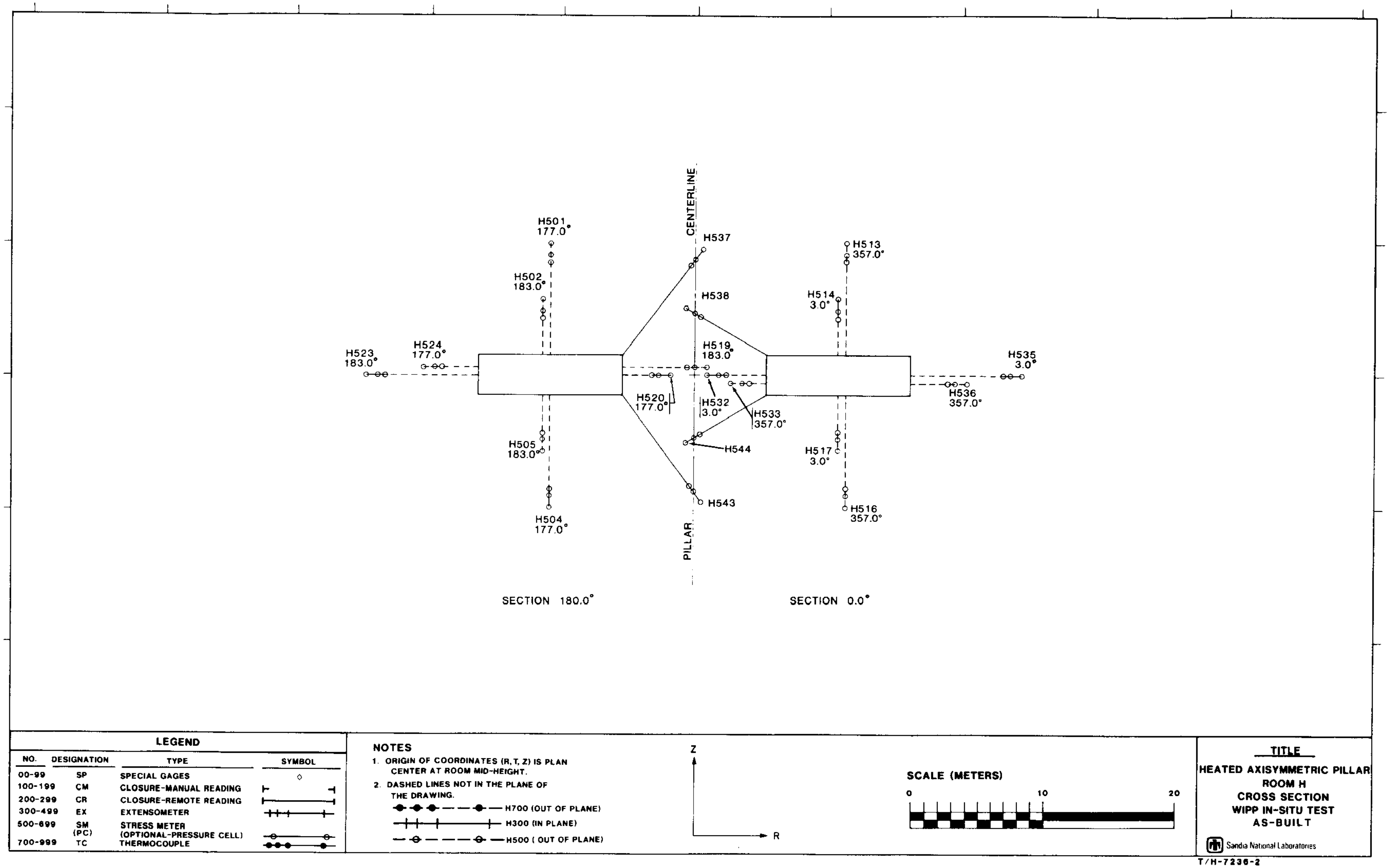

Figure 2.1.5. Cross Section of 0° and 180° Instrument Stations

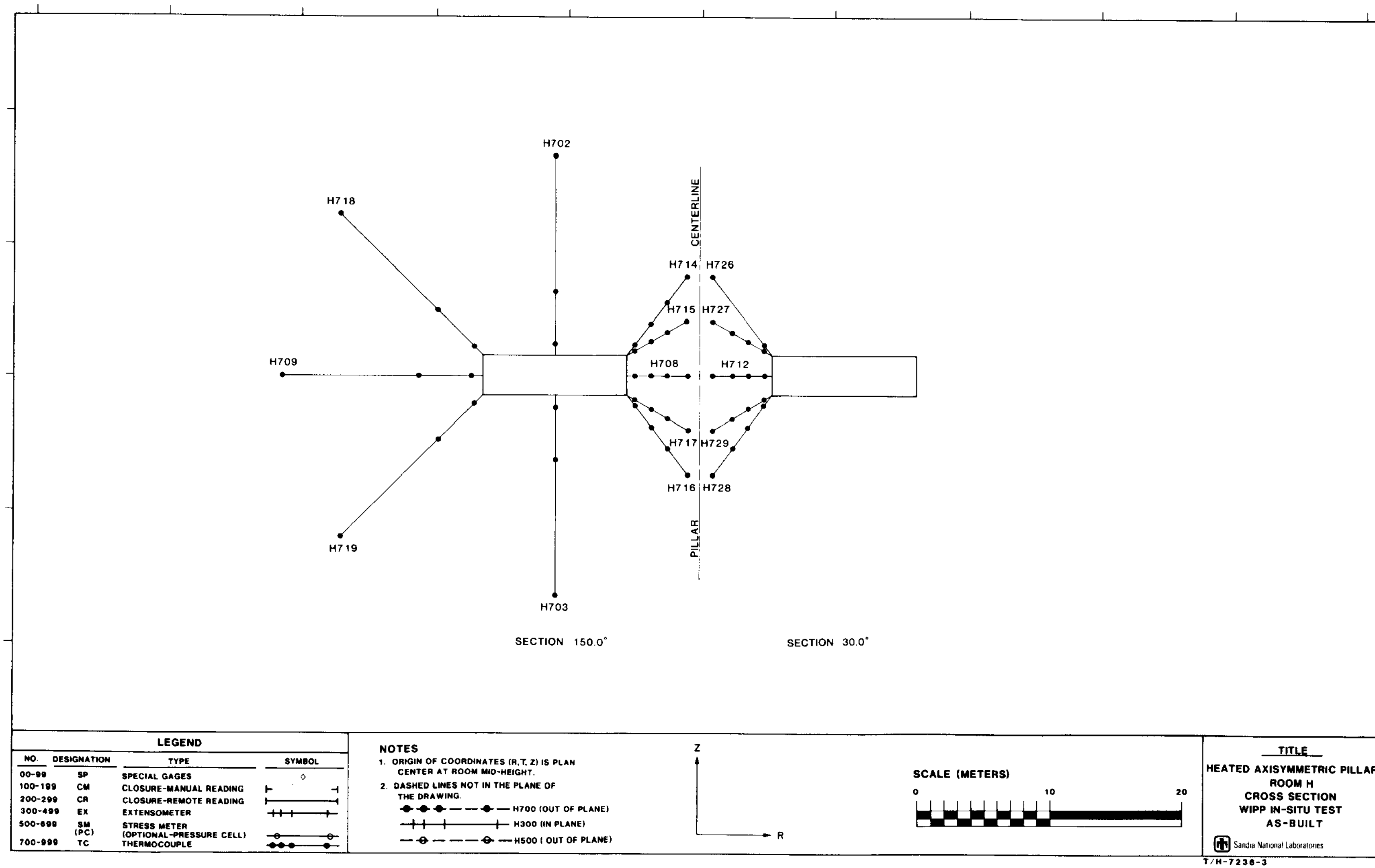

Figure 2.1.6. Cross Section of 30° and 150° Instrument Stations

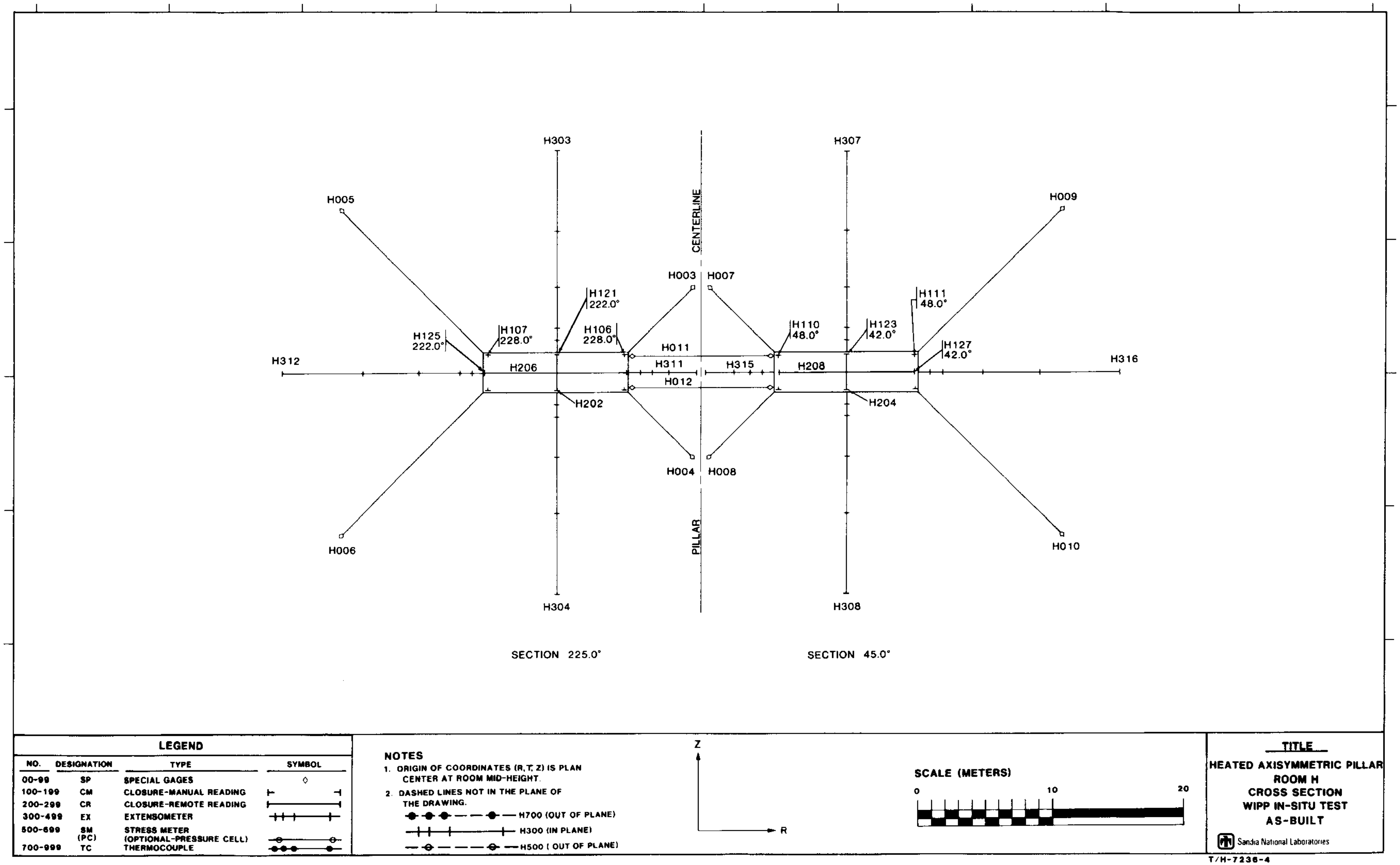

Figure 2.1.7. Cross Section of 45° and 225° Instrument Stations

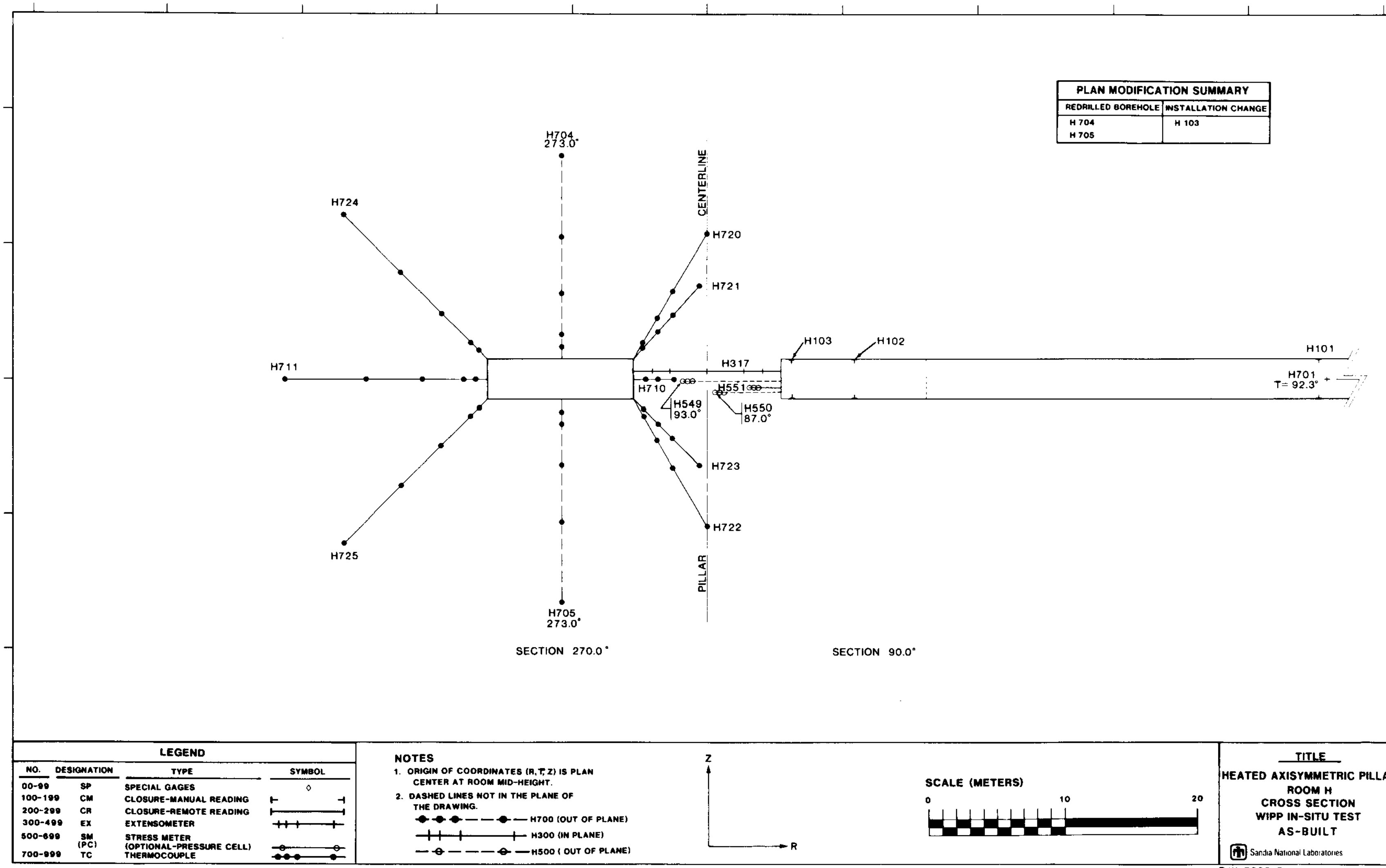

Figure 2.1.8. Cross Section of 90° and 270° Instrument Stations

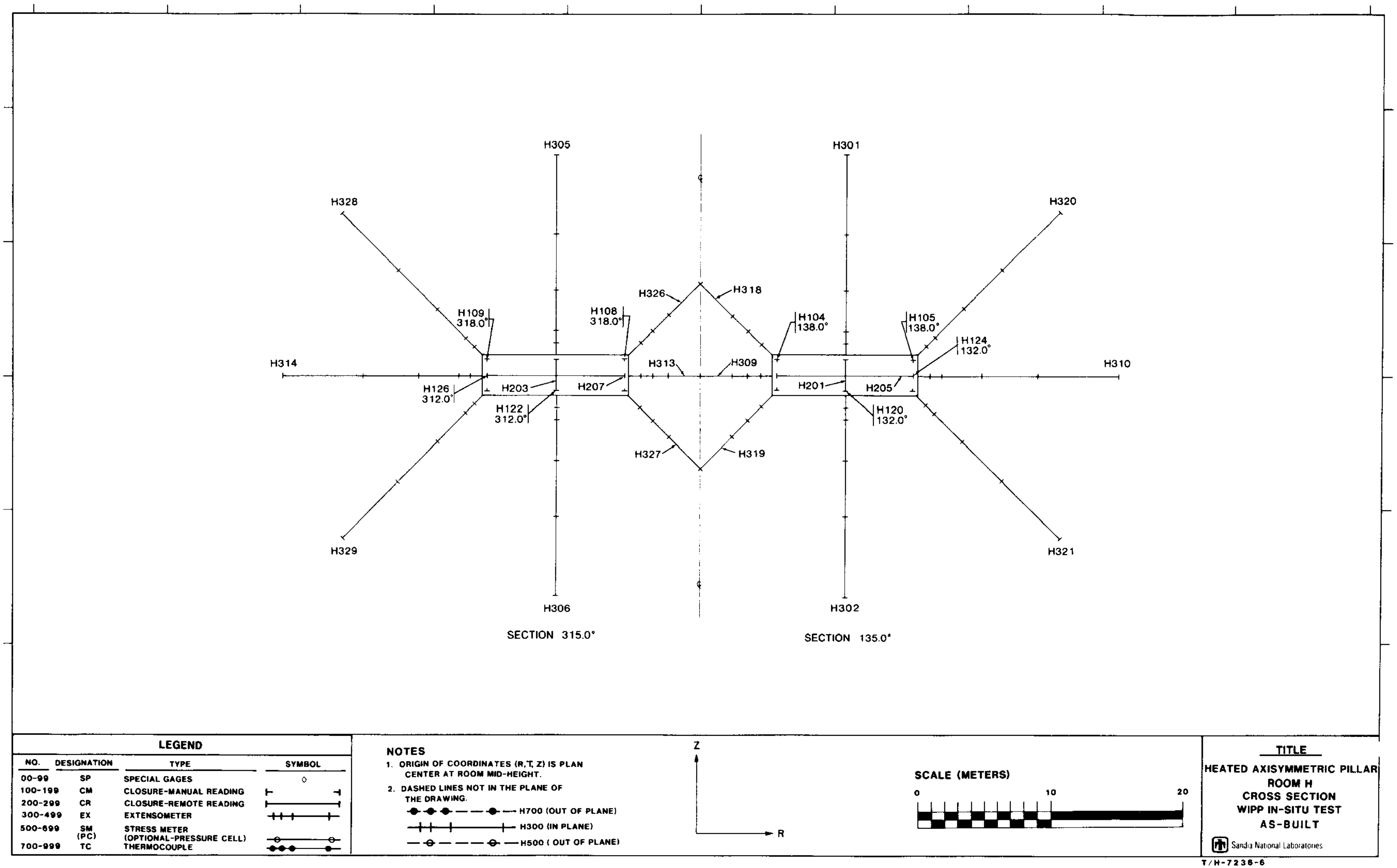

Figure 2.1.9. Cross Section of 135° and 315° Instrument Stations

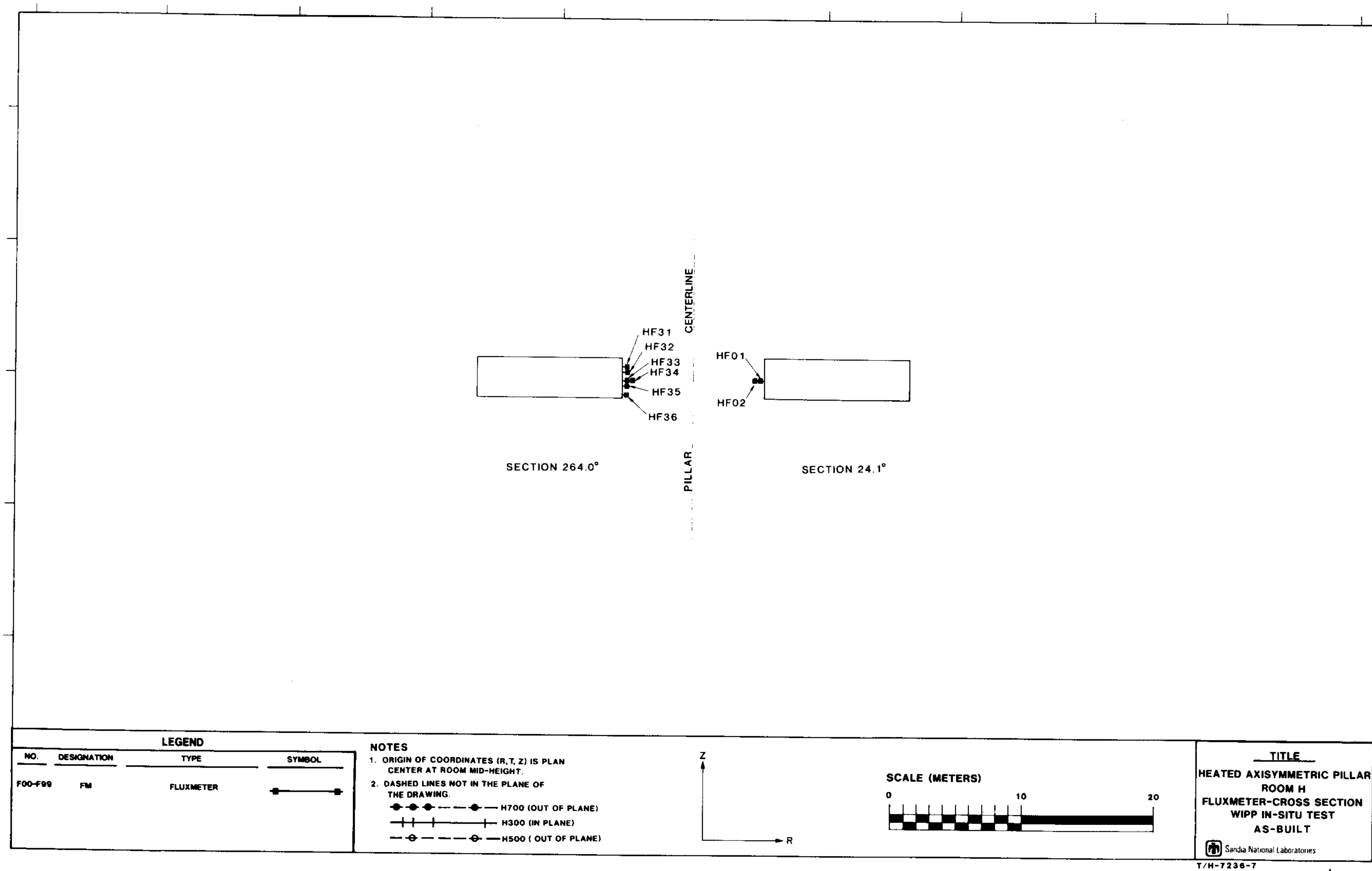

Figure 2.1.10. Cross Section of Flux Meters at 25° and 270° Stations

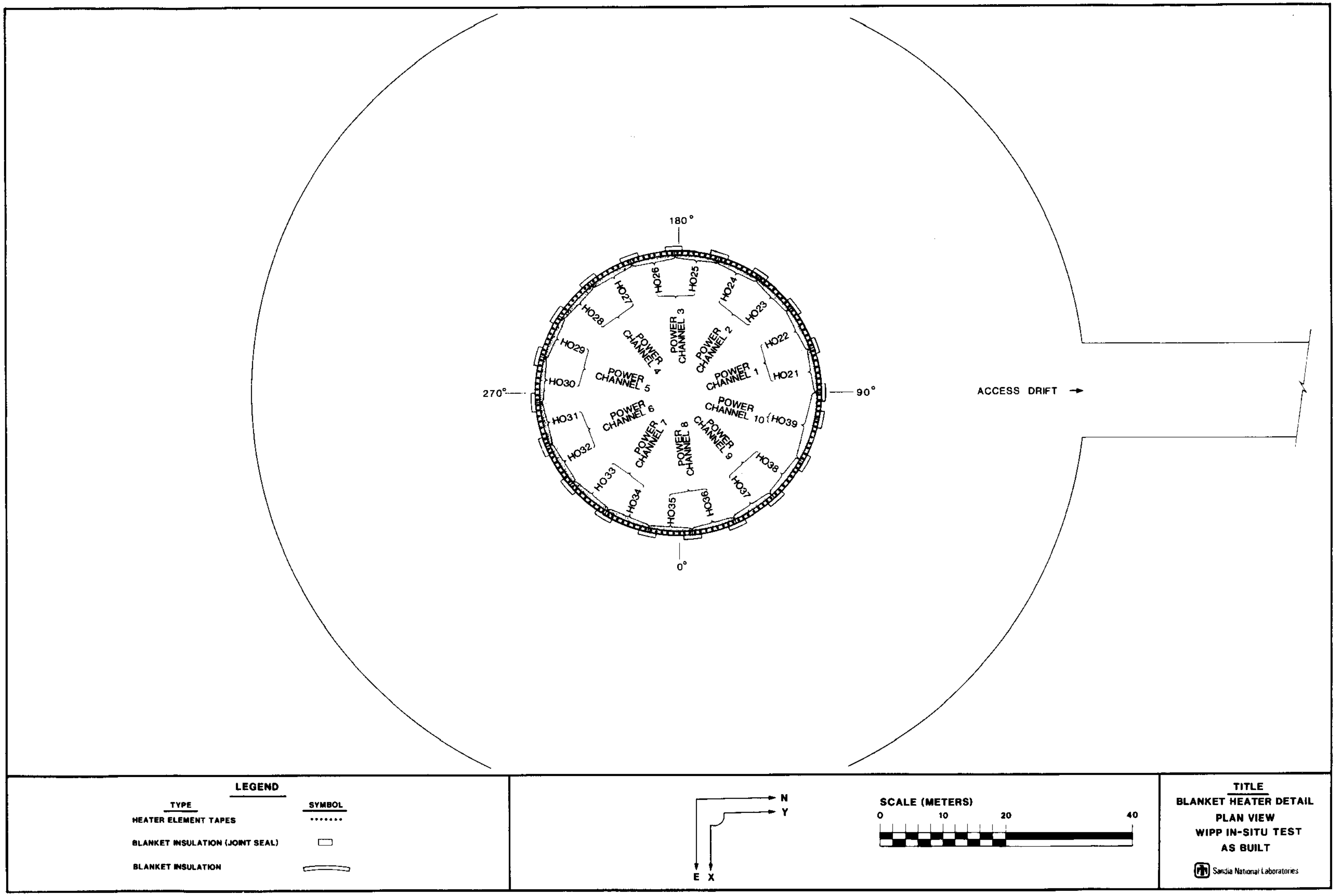

Figure 2.1.11. Plan View of Heater Tape Panels and Power Monitors

2.2.1 Mining: All mining excavation was done by a contractor under fixed-price constraints. Excavation of the room entry and room was by a Mitsui-Miike continuous mining machine. The room entry was mined in a single pass to a cross section about 3.05 m (10.0 ft) high by 3.66 m (12 ft) wide cross section between 4/16/84 and 4/21/84 in 5 days (12 shifts total). The entry excavation face was stopped at the surface of what would become the pillar. Some instruments were emplaced at this time in what would become the salt pillar. Mining activity ceased for 282 days before excavation of the test room annulus began. As shown in Figure 2.2.1, the room was cut in six passes: three major passes consisted of a central rough cut, a careful rib cut, and a careful pillar cut to make an upper excavation nominally 2.44 m (8 ft) high. These major passes were completed by three comparable minor floor passes (trims) to excavate the bench of remaining material to obtain proper 3.05 m (10 ft) room height. These passes were supplemented by intermixed trimming cuts, as necessary, to attain the proper room dimensions and surface smoothness tolerances. The first pass began 1/24/85 and the final floor trim was finished 2/13/85 in 21 days of continuous mining (59 shifts total). The nominal dimensions of the final pillar were 5.49 m (18 ft) radius and 3.05 m (10 ft) high. The final room was 10.97 m (36 ft) wide by 3.05 m (10 ft) high.

Room Excavation was documented in some detail, which permitted collection of complete face advance data. These data are presented in Figure 2.2.2. The two excavation phases are the room entry excavation (to the left in the figure) and the room excavation (to the right). Entry excavation was straightforward, progressing at nearly a constant rate throughout. Room excavation was more complicated. As shown, the

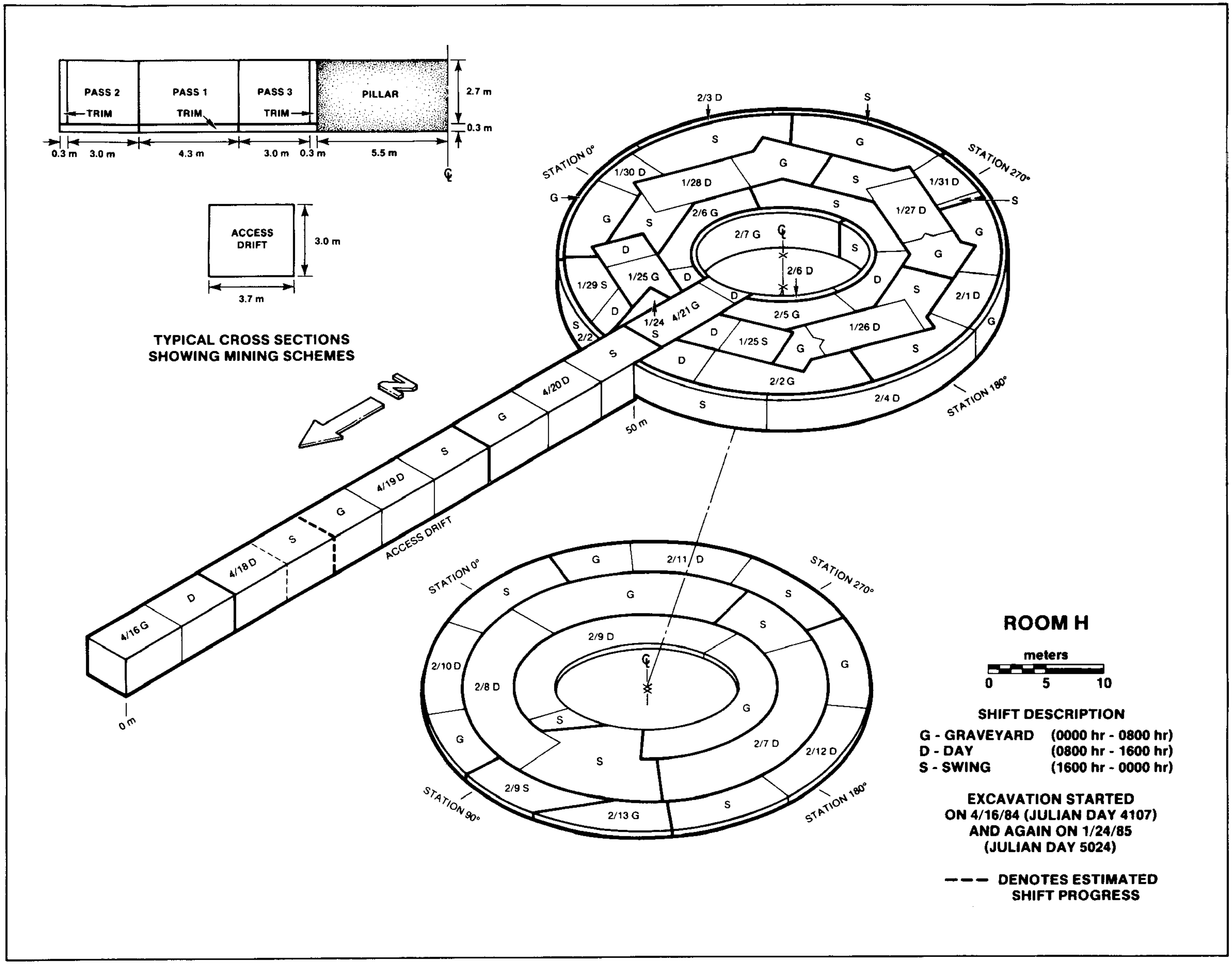

Figure 2.2.1. Isometric of Room H Excavation Progress

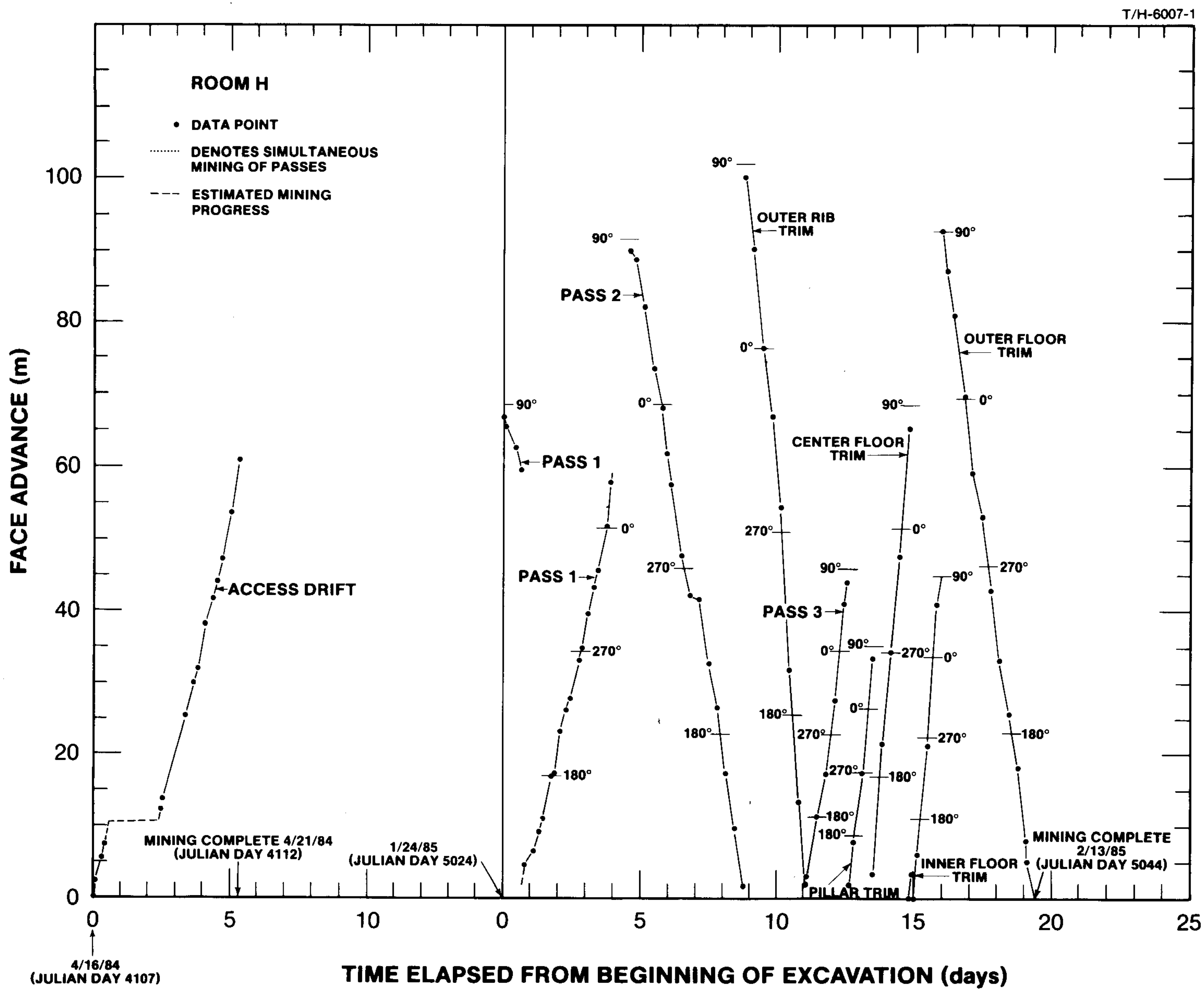

Figure 2.2.2. Face Advance During Excavation of Room H

excavation is represented as linear feet of face advance even for the annular room; however, the equivalent room coordinate angles are marked on the face advance curves. Exact excavation sequence can be deduced from the face advance curves. Room excavation began with a small, central, counterclockwise cut to make space for the mining machine. The machine was then turned around and made the major, central, clockwise cut. Upon completion of the central cut, the machine was turned around again to make the major rib cut and trim. The machine was turned around yet again to make the major pillar cut and trim. By turning the machine appropriately the operator was always in the best position to see and control the cutting head of the mining machine.

The minor floor passes (trims) can be traced, as well, through the detailed face advance data. These minor passes proceeded in much the same manner as the major passes. First the center and pillar floor passes were made, in that order. Then the machine was turned around to make the final rib pass (trim).

The room was set into the geology so that its roof was common to the previous underground excavations. This was done because a clear parting found throughout the facility at this horizon had to be followed to assure a stable roof. Thus, in all excavations, the roof (back) was the control on vertical location, and the floor elevation became the adjustable parameter of the excavation. The room coordinate center is at a depth of 645.3 +/- 0.3 m (2117 +/- 1 ft) below the ground surface. Also, the floor of the room is approximately 2.3 m (7.6 ft) above the Marker Bed 139 anhydrite layer of the '83 Reference Stratigraphy as given by Krieg [11]. Detailed mapping of the exposed stratigraphy in the room, and more

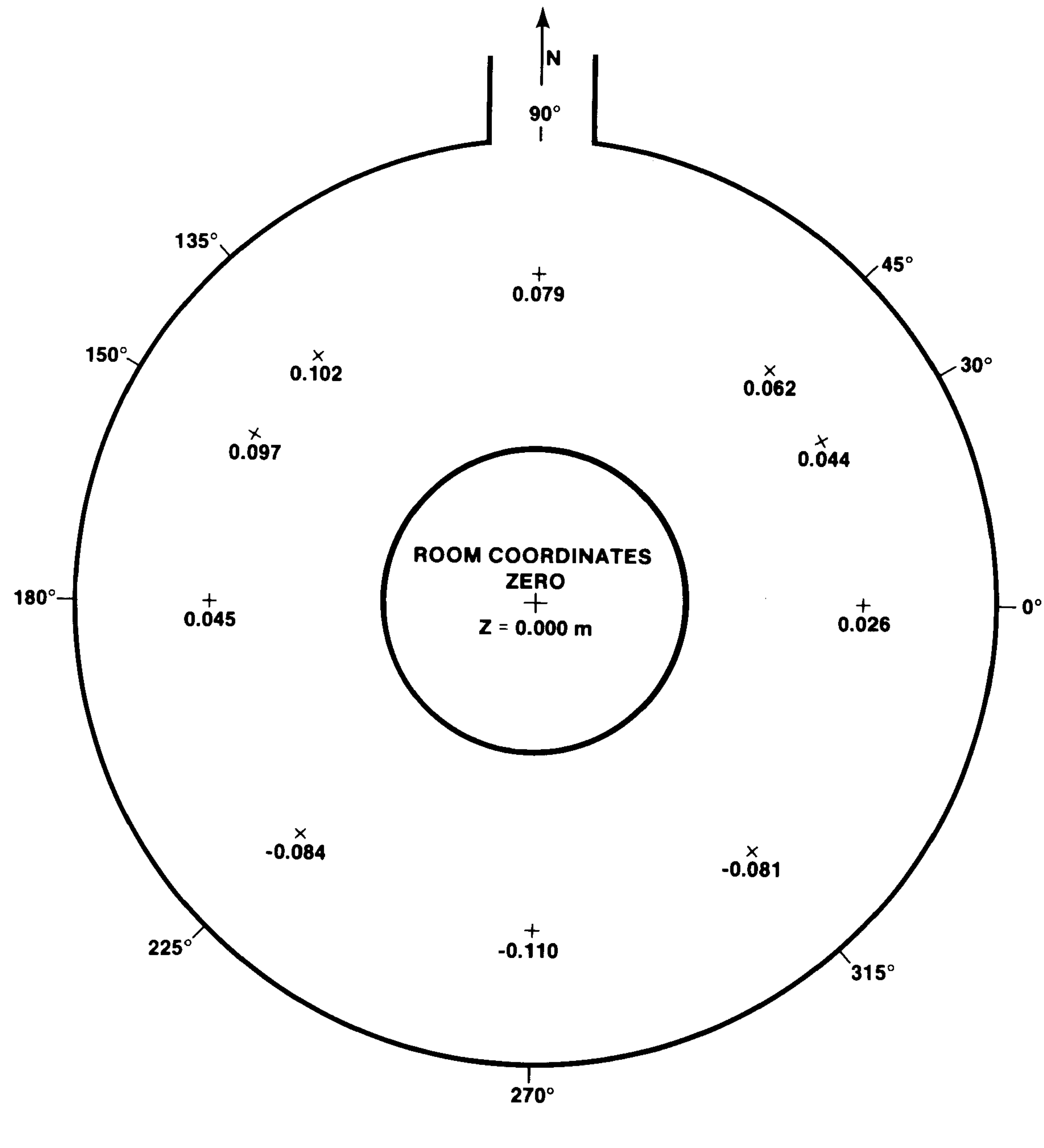

Figure 2.2.3. Stratigraphic Dip of Vertical Room Center

specific details of the near room stratigraphy can be found in the construction report [6]. A slight dip in the stratigraphy to the south resulted in a slight tilting of the room opening to the south. The actual magnitude of the dip was small, amounting only to 189 mm (7.44 in.) over the 21.95 m (72 ft) from the north room center to south room center, as shown in Figure 2.2.3. This produces an average dip to the south of only 0.49^{o}. In terms of analysis, the dip is insignificant and the room can be treated as having a flat-lying, horizontal coordinate system.

After the room was excavated, contractor drilling of the instrument boreholes started immediately. Drilling was completed within 21 days and the room was accepted from the contractor on 3/6/85.

2.2.2 Instrumentation: Sandia-controlled instrumentation teams were responsible for installing all gages, except the temporary closure stations included in the mining contract. The first gages were installed in the room entry. These early gages consisted of H 101, H 102, and H 103 temporary vertical closure gages in the room entry; of H 317, a temporary 6-point extensometer, and of H 549, H 550, and H 551, temporary stress meters, placed in what eventually became the pillar. A deep thermocouple gage H 701 was emplaced into the formation from the entry drift between the subentry and the room location. All these gages except the deepest of the H 317 extensometer points, which was mined out during excavation, are now permanent. The deepest anchor of the extensometer, after it was mined out, was eventually reinstalled at the pillar surface, which was at a shorter distance than the original anchor location. As a consequence, the measured displacements from this anchor reflect two different extensometer lengths, a fact to keep in mind when using the data from this gage. All these gages were giving data well before the mining of the room.

After acceptance of the room from the contractor, instrumentation of the room commenced immediately, and all permanent displacement and stress meter gages were in operation within 21 days. Thermocouples, flux meters, and heaters were installed at a more leisurely pace, but were operational well before heater turn-on.

2.2.3 Operation: The test has actually provided data since the beginning of mining of the room entry. The mining-sequence closure and temporary closure gages in the room entry, and the gages emplaced in what would become the pillar, have all generated data from that date. Similarly, the test itself essentially began with the initiation of mining and the collection of manual and remote data at that time. However, the completion of fielding of the Room H test was marked formally when the heaters were activated on 2/13/86. The room has been in routine operation since that date. This was 364 days, or nearly 1 year, after completion of room excavation; and 662 days, or 1.81 years, after completion of the room entry excavation. In routine heated operation, the insulated door is closed so that the room air is quiescent and heat loss is minimized. Room lights are usually off to eliminate this additional heat source.

Routine operation of the room involves any necessary maintenance of gages, including repair or replacement, if possible. It also involves the continued collection of data. The frequency of manual readings has diminished with time both because of availability of the remote-reading gages and because of diminishing deformation rates. The frequency of remote reading of all active remote gages remains constant at the initial frequency of a reading every 4 hours.

2.3 Special Features

Certain special features of the fielding of the in situ tests relate directly to the analysis of the data presented here. Except for some gages fielded as special groups, most gages were fielded in groupings at "principal stations," and many of the displacement gages were "linked" together, both physically or in time. As a further refinement of the test, gages and even principal stations are often related to each other by symmetry; and therefore a system of checks through gage redundancy is readily established for the test.

2.3.1 Principal Stations: The test was designed assuming an ideal, flat-lying, bedded-salt stratigraphy, which is also an assumption required for analysis using 2-D numerical models. It was necessary to adapt the ideal design conditions appropriately to the actual field conditions of slightly dipping beds. As noted earlier, the field conditions required following the beds because of clear partings in the roof. Actually, following the beds conforms to two-dimensionality because it preserves the fixed location of the opening with respect to the stratigraphy. However, location and installation of the gages over the total length of the room presented a problem. To minimize the problem, collections of gages were located relative to a local reference, called a principal station. Thus, it was possible to create a local reference at the principal station that was a flat-lying coordinate system with the origin centered vertically at a principal station. The local coordinate system was an orthogonal system in R (radius) and Z (vertical) directions and moved up and down according to the dip of the stratigraphy. Gages within about 1 m of the principal station were assigned to the station. As a consequence of the principal station concept, gages are given two sets of Z coordinates; one set is relative to the principal station zero, and the other set is relative to the test room coordinate zero. Use of principal stations not only simplifies fielding the gages but also aids considerably in analyzing the data. The small amount of dip in the actual room setting is automatically removed if the analysis is performed in principal station coordinates.

Although the cross sections of Figures 2.1.5 through 2.1.10 are related to the principal stations, and some indication of the gages associated with the stations can be determined from the figures, Table 2.3.1 organizes the gages according to their actual principal stations as emplaced. The table also gives the principal station WISDAAM System directory name as contained in the data base management system.

As previously noted, not all gages were associated with a principal station. These other special gages such as flux-meters are grouped together as indicated in Table 2.3.2.

2.3.2 Gage Linking: The Room H test, as well as all other TSI tests, were designed to obtain a complete data history, insofar as possible. To do this, we linked the gages in both time sequence and physical sequence. The following example shows primarily the time linking of the closure gages. For this example, the mining-sequence closure gage stations were placed in proximity to the locations of future temporary closure gage stations. The temporary closure stations were in turn located within about 0.30 m (1 ft) of the permanent closure station. As a result of this time linking, the very early closures obtained manually from the mining sequence station can be linked to the later closures obtained manually at the temporary closure station, and these can be linked in turn to the even

Table 2.3.1. Gages Grouped by Principal Station

Principal Station (Constant Theta)	Type	Units (Gages)
H ST000	Stress	H 513, H 514, H 516, H 517 H 532, H 533, H 535, H 536 H 538, H 544
H ST030	Temperature	H 712, H 726, H 727, H 728, H 729
H ST045	Closure(M)	H 110, H 111, H 123, H 127
	Closure(R)	H 204, H 208
	Extensometer	H 307, H 308, H 316, H 315
H ST090	Closure(M)	<u>H 101, H 102, H 103</u>
	Extensometer	<u>H 317</u>
	Stress	<u>H 549, H 550, H 551</u>
	Temperature	<u>H 701</u>
H ST135	Closure(M)	H 104, H 105, H 120, H 124
	Closure(R)	H 201, H 205
	Extensometer	H 301, H 302, H 309, H 310 H 318, H 319, H 320, H 321
H ST150	Temperature	H 702, H 703, H 708, H 709 H 714, H 715, H 716, H 717 H 718, H 719
H ST180	Stress	H 501, H 502, H 504, H 505 H 519, H 520, H 523, H 524 H 537, H 543
H ST225	Closure(M)	H 106, H 107, H 121, H 125
	Closure(R)	H 202, H 206
	Extensometer	H 303, H 304, H 311, H 312
H ST270	Temperature	H 704, H 705, H 710, H 711 H 720, H 721, H 722, H 723 H 724, H 725
H ST315	Closure(M)	H 108, H 109, H 122, H 126
	Closure(R)	H 203, H 207
	Extensometer	H 305, H 306, H 313, H 314 H 326, H 327, H 328, H 329

(Note: Underlined gages at Principal Station H ST090 are those installed from the room entry into the pillar material prior to the excavation of the annular Room H. M and R denote manual and remote, respectively).

Table 2.3.2. Special Gage Groups

Special Group Name	Type	Unit (Gage)
Flux H FX025	Flux	H F01, H F02
Flux H FX270	Flux	H F31, H F32, H F33, H F34, H F35 H F36
Heaters H HTR	Power	H 021, H 023, H 025, H 027, H 029 H 031, H 033, H 035, H 037, H 039

later closures obtained remotely from the permanent gage station. The distances between these different gages stations were intentionally minimized so as to introduce as little error as possible into the displacements when the data were linked to give the complete time history of salt displacements at a given station. Time linking of closure data is discussed and demonstrated in three earlier analysis papers [12-14] and is not treated further in this report.

Physical linking of the gages pertains only to the permanent displacement gages associated with a given principal station. Physical linking originates in the details of gage installation in collared holes. All of the permanent gages were installed on 0.53 m (21 in.) flanged pipe collars grouted 0.46 m (18 in.) into the salt. The outer flange surface of the collars served as the reference surface from which all distances were measured for installation, as-built surveys, and displacements. In the case of the multipoint extensometers, the remote permanent closure gages, and the manual water or optical level surveys, the gage or unit was attached to or measured at the collar reference flange surface. The sharing of a common reference surface means that the displacements measured by the appropriate linked gages at a principal station are in a continuous system and are exactly related to each other. As a consequence, well-defined displacement balances are possible.

An example of the principal station and physical linking concepts can be given for one of the principal stations in Room H. Figure 2.3.1 is a reduced-size composite of the linked displacement measurements at the 45° Principal Station. The small central schematic shows the location of the closure and extensometer gages. The horizontal alignment of reduced-size data plots shows the displacements of the salt from deep in the rib, across the room, and into the pillar. The vertical alignment of reduced-size data plots shows the displacements of the salt from deep in the floor, across the room, and into the roof. These reduced-size data plots are somewhat illegible here are be included full-sized later in the report (see Section 5).

A <u>note of caution</u> is given here. Although the displacement gages were physically linked while fielding the gages, it was not possible to field the gages simultaneously. Therefore, the time distribution of the fielding of the gages causes the origin of a given gage data to be shifted by some amount in <u>both time and displacement</u> with respect to the other physically linked gages. The procedure for correctly reconstructing the displacements to correct for the lost displacements caused by the time shifts are not discussed in this report; only the reduced data are presented here. Reconstruction to account correctly for all installation time shifts is more properly an analysis activity, because it requires knowledge of the constitutive model of salt behavior and appropriate numerical calculations. Also, the time correction for the linking of

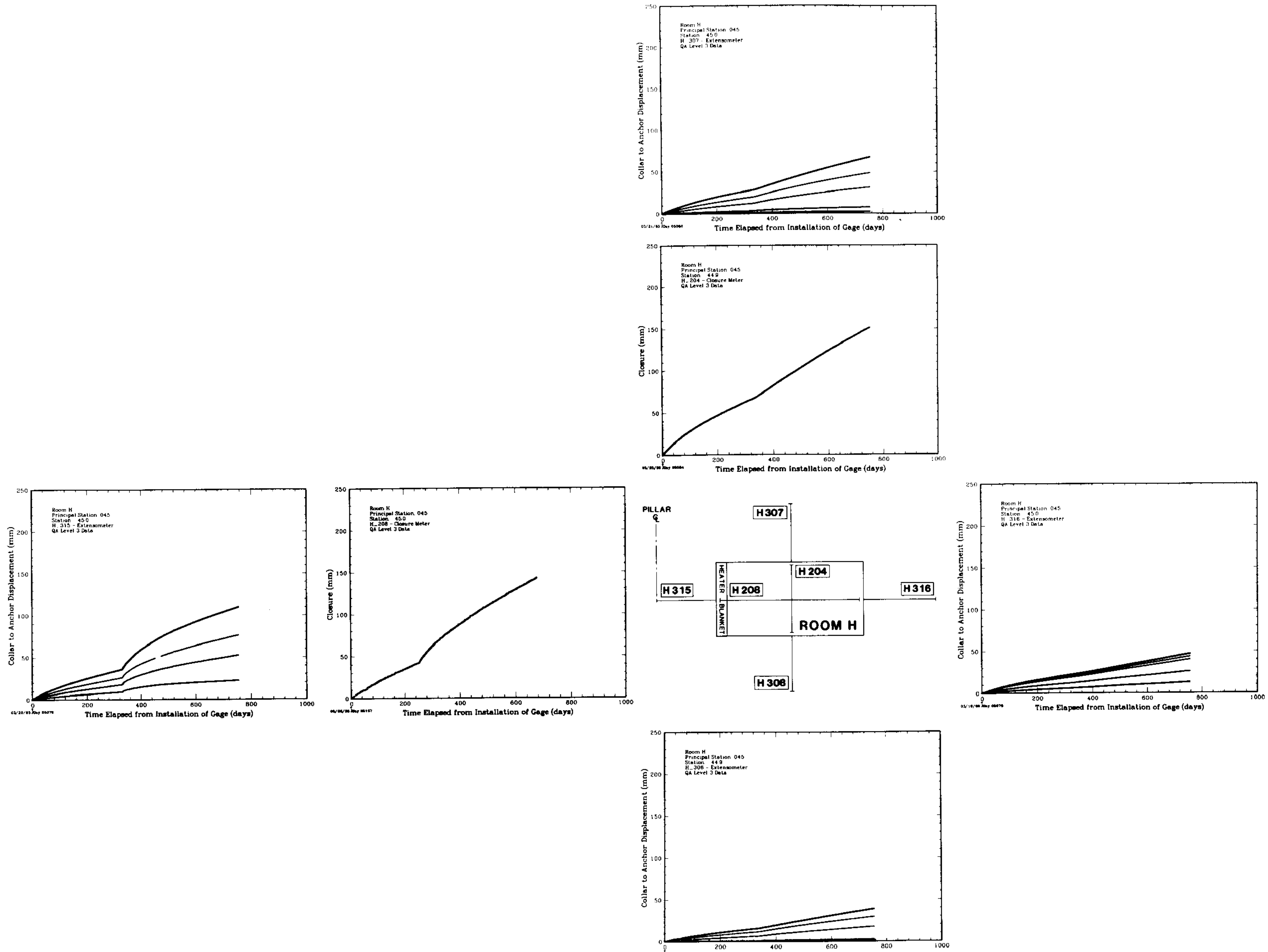

Figure 2.3.1. Reduced-Size Composite of Closure and Extensometer Displacements at the 45° Principal Station

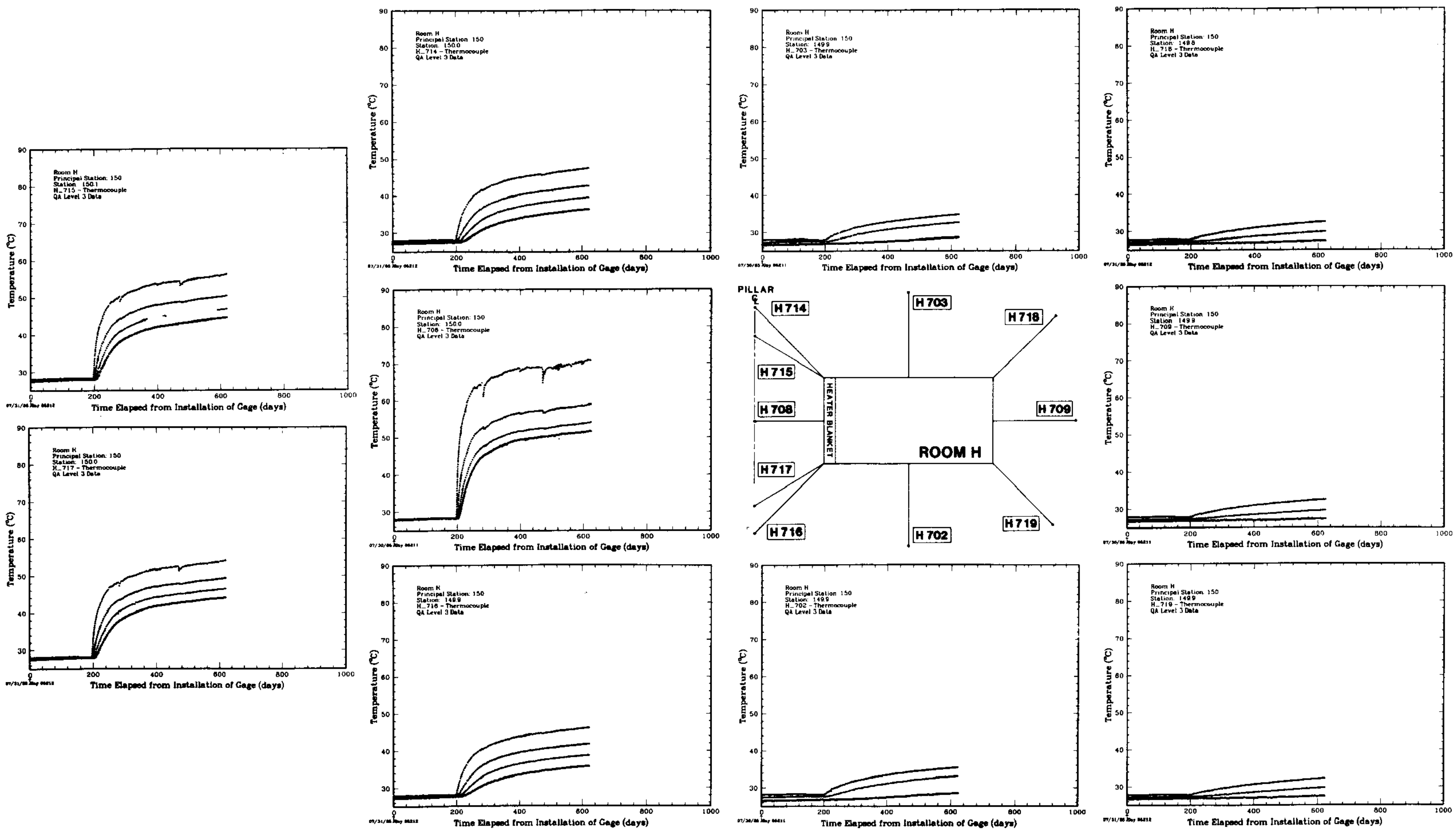

Figure 2.3.2. Reduced-Size Composite of Temperatures at the 150^o Principal Station

displacements will involve not only the physically linked gages but also the earlier displacements of the mining-sequence and temporary gages.

Although not physically linked in the rigorous sense of the displacement gages, other gages such as thermocouples grouped at a principal station are also essentially linked together. In this case, the link is that the gages together give a complete history of the response around the station. An example of the temperature history from the thermocouples "linked" together at Principal Station 150^{o} is shown in the reduced size composite of Figure 2.3.2. Legible full-sized temperature plots for all the reduced-size plots on the composite are included later in the report (see Section 5).

2.3.3 Special Gage Groups: There are collections of gages that have special relationships to each other, even though they may be distributed throughout the test room. These gages form logical groups that are treated as an analysis entity because they describe an important material or room response, or they provide a necessary parameter for the experiment. Special gages in Room H are few, representing only the mining-sequence closure gages, the preexcavation gages emplaced in the pillar material, the heat flux gages, and the power gages.

3 DATA REDUCTION PROCESS

The critical nature of data used in any development or process involving repositories for the disposal of radioactive waste requires that all data collection, reduction, and analysis must be formally documented. This documentation formalism is certainly necessary even for the R&D activities of the Technology Development Program, of which the TSI in situ tests are a part. Data reduction forms a special part of a larger data collection, analysis, management, and documentation system developed for the in situ tests. This larger system is the WIPP In Situ Data Acquisition, Analysis, and Management (WISDAAM) System [9]. The important parts of the system for this data report are the data reduction and Quality Assurance (QA) procedures.

3.1 WISDAAM System Functions

Input to the raw data base is either manual (paper forms) or remote (computer). Both types have large associated data bases. Incorporating them into a single, quality-controlled, reduced data base requires care and some effort.

3.1.1 Manual Data: Manual data, handwritten records concerning nearly all aspects of the in situ tests, include far more than just the actual gage data. For this report, only the manually taken gage data concern us. These data are collected on special forms and placed into the WISDAAM, QA-controlled, Notebook System as raw data. This Notebook System, an appendix to the Test Plan for Room H [5], is maintained in the WIPP Central Files of the Waste Management Technology Library at SNL. From the raw data base, the data are entered into a computer-based management system using dBase III and reduced at individual work stations on IBM-AT computers. The result of the data reduction process is QA Certified Data. These certified data are transferred to the overall data base management system installed on the central WISDAAM System data base management MicroVAX II computer. Detailed explanations of the reduction process and the exact procedures for manual data are available [15].

3.1.2 Remote Data: The remotely collected data come from the automated data acquisition system at the WIPP site [8]. Analog voltage data from individual gages are periodically interrogated by digital voltmeters located in underground instrument sheds adjacent to the in situ test. The digital data are transmitted by wire from the underground shed to a ModComp Classic 7840 computer at ground surface. These data constitute the raw remote data base. From raw voltages, gage calibrations, and conversion factors, raw engineering values are calculated and stored as part of the raw data base. Periodically, the data are transferred to magnetic tape and transported to the central WISDAAM System data management MicroVAX II computer. These tapes are considered part of the WISDAAM, QA-controlled, Notebook System and are also retained in the Sandia WIPP Central File. When the tapes are entered into the MicroVAX II computer system, the raw data are compressed and then reduced, and the resulting certified reduced data are stored in the MicroVAX II computer. Descriptions of the computer software, the data reduction system, UNDERDOG, and the procedures for reduction of remote data are available [16].

3.2 Quality Assurance (QA) Requirements

Extensive QA procedures have been practiced before, during, and after fielding the in situ tests. These QA procedures begin with the Sandia

Quality Assurance Program Plan for the Waste Isolation Pilot Plant (WIPP) [17] and the specific QA requirements of the individual test plans. Although the overall QA has many implications for the data, we are concerned here only with the specific practices that relate to the data reduction process. The reduction process is compatible with overall QA requirements and includes QA features peculiar to a working data reduction system and the WISDAAM System. As a necessary requirement of the QA practice, all the raw and reduced data bases are periodically archived on long-lived (about 25 years), maintenance-free, optical disks.

3.2.1 Reduction Levels: Because of the massive amount of raw data, the high level of overall QA, and the need to document the reduction process, the TSI program has defined several levels of data reduction associated with very specific activities and treatment of data:

Level 0 ---- Raw data in the form of magnetic tape or paper records. Remote raw data are stored in the MicroVAX II computer; manual raw data in the Notebook System.

Level 1 ---- Remote data compressed by removal of nondata zeros, system flags, and redundant (values identical within the least significant figure) data; and manual data entered into the MicroVAX II computer data base.

Level 2 ---- All documented, known-cause corrections to the manual and remote data are made to the data and noted.

Level 3 ---- All undocumented, known-cause corrections to the manual and remote data are made and noted.

QA Stamped - Level 3 data, PI approved as Certified Data, published in a data report, and available for use in analysis.

Level 1 data reduction is fairly straightforward. Because raw remote data are collected on a very frequent schedule, many of the readings change only in the places beyond the least significant figure. Thus, readings that are identical to the place of the least significant figure are redundant, and only one value needs to be retained. At Level 1, the raw manual data simply are transferred under close QA checks to a computer data base.

Level 2 data reduction for both remote and manual data are the corrections taken when a planned or inadvertent human activity involving the gage or data acquisition system alters the gage reading(s). Examples are power failure, gage maintenance, gage replacement, and intentional or accidental disconnection of a gage. Because of the nature of the human activity, and because of the QA requirement to document that activity, the exact time and the exact activity are known. Correction procedures for these activities can be determined routinely and employed properly in the data reduction.

Level 3 data reduction activities are basically routine and involve a known problem of the gage response that is not the result of a planned or accidental human action. These problems are the result of gage peculiarities or uncontrolled events. Examples are gage hysteresis, an unpredictable event controlled by the gage; low-resistance shorts to ground because of collection of moisture; an undetected reading error; or a necessary routine reconstruction of zeros because of destruction of a gage point. When these events occur, it is apparent from a characteristic signature of the gage response; thus corrective data reduction actions can be determined and applied routinely.

In developing the data reduction procedures, we were extremely careful to assure that no activity was in the realm of analysis. In other words, no modifications or corrections were made during data reduction that required the application of abstract concepts, scientific judgments, or fundamental interpretations. The reduction levels were applied rigorously. All data reduction was documented by level for each gage, and these records form an important part of the data base.

3.2.2 QA Stamped Data: After data reduction has been applied to a given gage and the data have progressed to the completion of Level 3, the Principal Investigator (PI) carefully checks to determine that (1) all reduction activities are proper, (2) all relevant data for the gage are included in the records, and (3) all QA requirements have been fulfilled. At this point, the PI is responsible for application of the QA Stamp to the data, which then is Certified Data. QA Stamped or Certified Data are releasable to analysts for their use.

All the data in this report are Certified.

4 REDUCED DATA PRESENTATION

Presentation of the large quantity of data from the Room H Test, in exactly the manner matched to the needs of any specific analyst, is quite difficult. We can, however, present the data in a reasonable form and provide several keys that permit the analyst to find readily the desired collection of data. The first key is found in Tables 2.3.1 and 2.3.2. All gages belonging to a principal station or a special group are shown in these tables, which gives the analyst a comprehensive overview of the instruments in the test. Analysis might logically center on a principal station or special group. As noted previously, the gage number (designation) contains specific gage information which indicates the test room, gage type, unit number, and gage number. Thus, it is possible to determine the gage type directly from the gage number. Each gage type is presented in an individual section, with the gages given in ascending numerical order. At the beginning of each of the sections, another key is a location guide (table) showing the schematic location of each of the gages of that type by principal station. Use of the guide permits identification of specialized groups of gages peculiar to the needs of the analyst. From the guide, for example, all the gage numbers for the vertically up gages can be readily identified. Also, gage numbering generally follows a systematic pattern to aid in identifying direction or location.

Because of the importance of the data obtained from the gages emplaced in the pillar material from the room entry before room excavation, these data are presented together in the initial section. These individual gages are repeated later in their appropriate section. Thereafter, all the data are presented in sections according to individual gage type, beginning with closure data (manual and remote), and then extensometer data, stress meter data, temperature data (for Room H this is only the far-field or rock mass temperatures), and special heat flux and heater power gage data. All data in each section are presented by gage number in ascending order.

The format for each gage (in most cases a unit consisting of several gages) includes first the PI Comments on the quality and important aspects of the data reduction and, second, the Location table specifying location and other relevant information concerning the unit (gages). The location of the gage is given in both room and principal station coordinates. Data for the gage(s) are then shown graphically.

Let us consider only the remote gages. Several items in the PI Comments on remote gages themselves require some explanation. First, the comments indicate the date of the evaluation, the initials of the person(s) responsible for the data reduction, and a ranking of the gage. The ranking relates almost automatically to the collection quality of the data, but not to the correctness of the data. In other words, the data could have very little meaning in terms of analysis and physical correctness and still have a high rank. Thus, the rank is actually more of a measure of the type and number of reduction actions taken during the reduction process and the severity of the actions. In the case of stress meters, thermocouples, and flux meters, the rank is given as a percentage of data retained after elimination of obviously scattered and erroneous data. A specific scale of actions was used to determine the rank value of a gage:

Rank 10 Outstanding. Very minor shifts or deletions of data, of which 95% or better are at Level 2, or data retention of 95% or better.

09 Exceptional. Reinstallation shifts and minor shifts and deletions of data, of which 90% or better are at Level 2, or data retention of 90% or better.

08 Excellent. Some additional minor deletion of data because of hysteresis at Level 3, or data retention of 80% or better.

07 Very good. All reduction actions to some degree, including up to 30% at Level 3, or data retention of 70% or better.

06 Good. All reduction actions, with marked deletions because of hysteresis, or data retention of 60% or better.

05 Fair. Marked shifts and deletions of data because of hysteresis, with up to 50% at Level 3, with some of the major shifts undocumented at Level 2 (called arbitrary), and possible swapping of data channels or entanglement of wires, or data retention of 50% or better.

04 Marginal. Marked arbitrary shifts, major deletions of hysteresis, and unknown scatter, or apparently entangled gages requiring adjustment according to other gages, or data retention at only 40% or better.

03 Poor. Required excessive reduction, with adjustments according to other gages and sources, or data retention of only 30% or better.

Rank 02 Very poor. Excessive reduction, with reporting of data only for possible supporting information, or data retention at 20% or better.

01 Unacceptable. Reported primarily to show experimental problems, and data retention less than 20%.

00 No data. No data reduction possible for gage.

The PI Comments conclude with the Level 1 compression ratio for the unit or gage. The completely automatic Level 1 reduction for remote gages includes data compression. Data are compressed according to three rules: (1) data that are identical to within the least significant figure (range) are redundant, and only one data point needs to be retained. (2) a data point will be retained every 3 days even though it may be redundant. (3) if a data point is retained on any gage of a unit, all comparable data points on that unit are retained.

For all TSI remote-gage data, the least significant figures (ranges) are:

Time: 0.001 Jday (15 min).

Closure (displacement): 0.10 mm (0.004 in.).

Extensometer (displacement): 0.10 mm (0.004 in.).

Stress (pressure): 0.007 MPa (1.0 psi).

Temperature: 0.1°C (0.056°F).

Flux: tied to temperature data of the unit.

Power: 1.0 W.

Note that an option during Level 3 data reduction permits a similar compression of data. This recompression option does not affect the previous Level 1 compression ratio. The option is often applied to units where data scatter on one gage causes excessive retention of redundant data on the other gages of the unit. It is also applied to the data of gages where the least significant figure was intentionally small, such as the flux and power data. Intentionally small significant figures were usually chosen when it was not possible to set a reliable value for a given gage type. After the fact, the observed scatter suggests a reasonable recompression for that gage.

PI Comments for the manual data differ from those above for remote gages. The manual gage data were not ranked since reduction actions were quite limited and involved few data. Also, there was no Level 1 data compression for these data, and so the compression ratio of 1:1 applies.

The Location information gives the theta coordinate of the principal station designation and the actual station for the unit or gages. Then tabular entries present the gage number, type, initial gage status (permanent or temporary), recording method (remote or manual), the direction (vertical, horizontal, or diagonal), the R,T,Z coordinate pairs for both ends of the gage, with sets of Z in both Principal Station and Room coordinates, gage manufacturer, initial installation date, purchase order and item number, and comments.

Facing the PI Comments and Location page is a graph of the data for the unit or gage. Several items are included to aid the viewer. The room, gage (or unit) number, type of gage, station and principal station are shown in the upper left corner. In most cases, a cartoon cross section showing the physical location of the gage(s) is given in the upper right corner. The cartoon gives the symbol legend for the gages. Thus, a square symbol is always gage 1, a diamond gage 2, an x gage 3, a triangle gage 4, a circle gage 5, and a + gage 6. In some cases the cartoon is replaced by a conventional symbol legend. Also, the origin is linked to the calendar and Julian day (Jday) on which the gage was installed. An abbreviated form of Julian day is used in which the first number is the last digit of the calendar year and the remaining numbers are the total days of the year to that day. Consequently, it is possible to arithmetically manipulate Julian days in modulo 365 (leap year 366). All the reduced manual data are included on the graphs of these data. However, to make the graphs of the remote data clearer, we eliminated many of the actual data points so that the symbols are distinct. This is not a true Level 1 recompression. If this were not done, the data would have been so dense that the symbols would be illegible. Another interesting and potentially useful feature of the graphs is that the engineering values of the ordinate and the time values of the abscissa axes of like graphs are normally plotted to identical scales and can, therefore, be compared directly by overlaying them.

5 REDUCED DATA

Before we discuss the data of each gage type, please note a very significant appraisal of data quality: the data about to be presented are of truly high quality. This is noteworthy because they were obtained from a large-scale underground field test under sometimes harsh and congested environmental conditions and under occasionally difficult operational constraints. They would be judged of superior quality even against typical laboratory data obtained under ideal conditions. With time, of course, deterioration of the test is expected through gage failure.

The data return was also remarkable, by any measure. Every gage fielded produced data. Only one gage failed to return early data; it was inadvertently not connected for recording for about 100 days. Out of the 321 remotely read gages, this represents only 0.3% loss of early remote gage data. Since the beginning of the fielding of the experiment, for gages not failed, the data return has been above about 95%. By this we mean that no more than about 5% of the data were deleted during reduction as a result of all causes at both Level 2 and 3. One can conclude correctly from this that the effects of gage maintenance, computer acquisition errors, electrical scatter, and hysteresis were insignificant or at least not detrimental to the data. The data return from the manually read gages is even higher than from the remote gages. The principal causes for loss of manual gage data were lack of access to the gage because of mining activity, and gross reading errors. Both causes resulted in minor loss of data, with more than about a 98% total return of manual data from the 40 manual gages (excluding the 10 inclinometers not reported here) and the 9 mining sequence gages.

Failure of gages was quite low. Here we consider failure to mean a nonmaintainable condition leading to obviously incorrect data and, possibly, discontinuation of the measurement. As of the date covered by this report, all the manual gages continue to be maintained and read, although at reduced frequencies. By the stated standard, none of the manual gages can be considered failed. The remote gages, of course, show some failures. All the remote <u>closure</u> gages and remote <u>extensometer</u> gages are extensively maintained, and none has failed; however, one was mined out and the anchor eventually replaced at a new depth. The 69 stress meters, because of their fixed emplacements, are maintainable only to a minor degree. As a consequence, a significant number have failed. All except one of the 9 SGS gages emplaced early into the pillar material have now apparently failed. Of the 60 BuMines CPC or BPC gages, 18 gages have certainly failed, with another 3 or 4 suspect and probably failed. Thus, about 43% of the stress meters have failed or are suspect at the time of this report. Principal failures occurred to stress meters in the pillar. All 100 thermocouples continue to function, with only 2 gages suspect. Failures of the flux meters, as with the stress meters, are high. Flux meters are permanent emplacements of a very fragile gage, and so the failure rate is no surprise. However, of the 8 flux meters, only 1 gage is suspect. All 10 power meters are functioning properly, as expected.

If the above figures are taken at face value, then the total Room H known gage failures to date (excluding the inclinometer and mining sequence gages not reported here) are only 26 of a total 361 gages, or 7.2%. This is remarkable for an experiment exceeding 1000 days for some gages and 600 days for most gages.

5.1 Early Pillar and Room Entry Measurements

Data for the early room entry closure gages are given in Tables 5.1.1a-c and Figures 5.1.1a-c. Early pillar response extensometer data are given in Table 5.1.2a and Figure 5.1.2a, and stress meter data are given in Tables 5.1.3a-c and Figures 5.1.3a-c. Data for the room entry thermocouple are given in Table 5.1.4a and Figure 5.1.4a.

The responses of the room entry drift is quite interesting and complex. Vertical closures (Figures 5.1.1a-c) of the entry drift measured by H 101, H 102, and H 103 during the first year show an effect probably related to the proximity of the earlier TRU Test Panel excavations (see Figure 2.0.1) to the north and east of the entry. Measured closures are a function of the distance from these earlier excavations, with the H 101 gage at the midentry location yielding displacements more than 50% greater than those at H 102 near to the end of the entry. This is in agreement with earlier conclusions about the closures of the South Drift [18,19] and of Room D [13], which suggest a greater extent of the deformation radially into the salt than expected from design calculations [20]. This is also in accord with the earlier hydrofrac stress determinations of Wawersik [21], who found the stress disturbances from the TRU Test Panel were more pervasive than expected. In the hydrofrac test results, stress field disturbances attributed to the earlier excavations appeared to extend up to about 52 m (171 ft) away from the TRU Test Panel.

The mining of Room H is reflected strongly in the entry closures. The influence of room mining can be determined by examining the room entry closures after beginning of room mining, about day 240. As expected, the greatest closure occurs at the H 102 gage at room midspan, which also happens to be the gage at the room entry/room intersection location. For the closures measured after day 240, H 103 at the pillar surface measured only about three-quarters of the displacements measured at room midspan. However, a noticeable increase in closure as the result of room mining occurs even at the midentry H 101 gage. Later in the records of the closure gages, at about 600 days a relatively abrupt increase in closure occurs in response to activation of the heaters.

The extensometer measurements of H 317 are taken through the pillar, at a vertical location about three-quarters up the pillar. Preliminary calculations suggest that the pillar deformation conserves volume and is therefore nondilatant. In the record of Figure 5.1.2a, the abrupt increase in displacement at about 600 days is again the response of the pillar to heater turn-on.

Stress meter response of the early pillar gages is too complex for any simple explanations. Changes in the indicated gage stress may be caused by real changes of the room induced stress field in the surrounding salt or by attempts of the gage to come into equilibrium with the local stress field around the gage emplacement borehole. Proper interpretation of the gage response therefore involves sophisticated numerical calculations through the use of proper constitutive models and exact representations of the physical situation. It can be said, however, that the SGS gages, which are relatively stiff, show a marked increase in readings as the room is excavated. All records, except H 440-2, appear to plateau some time before failure. Until these data are properly analyzed, it will not be known if the observed loss of stress is, indeed, an indication of the failure of the gage.

H 701, a deep far-field thermocouple, shows a very gradual increase in temperature with time. This 1^{o}C increase is most probably unrelated to the pillar heating because it does not begin concurrently with initiation of heating. Rather, it is caused by the fact that the mean virgin ground temperature is about 1.5^{o}C colder than the mean temperature of the ventilation air. Consequently, the far-field temperature will gradually increase with time. As will be seen in the records of most of the thermocouples nearer to the openings, there is a sinusoidal out-of-phase seasonal temperature variation that damps in amplitude with distance away from the openings. Since the variation is out of phase, it is related to thermal conduction in the salt. Also, the mean of the sinusoidal variation increases with time, indicating that the mean air temperature is greater than the initial salt temperature.

Table 5.1.1a. Early Room Entry Closure Gages, H 101

Gage: H_101

****

***** H_101 PI Comments *****

11/23/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS GAGE IS APPROXIMATELY IN THE MIDDLE OF THE ROOM H ACCESS DRIFT. UP TO DAY 283 IT IS MEASURING JUST THE RESPONSE OF THE ROOM ACCESS DRIFT. AFTER DAY 283 WHEN MINING OF THE ROOM H PROPER STARTED, IT IS MEASURING NOT ONLY ITS OWN DISPLACEMENTS BUT ALSO THOSE INDUCED BY THE MINING OF THE ROOM. (DEM)

***** H_101 Location *****

Principal Station 090
Station 90.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_101-1	CONV	T MAN	V	45.99	45.95	89.96	89.94	-1.53	1.53	-0.69	2.38	SNL	04/19/84	T91025-000	

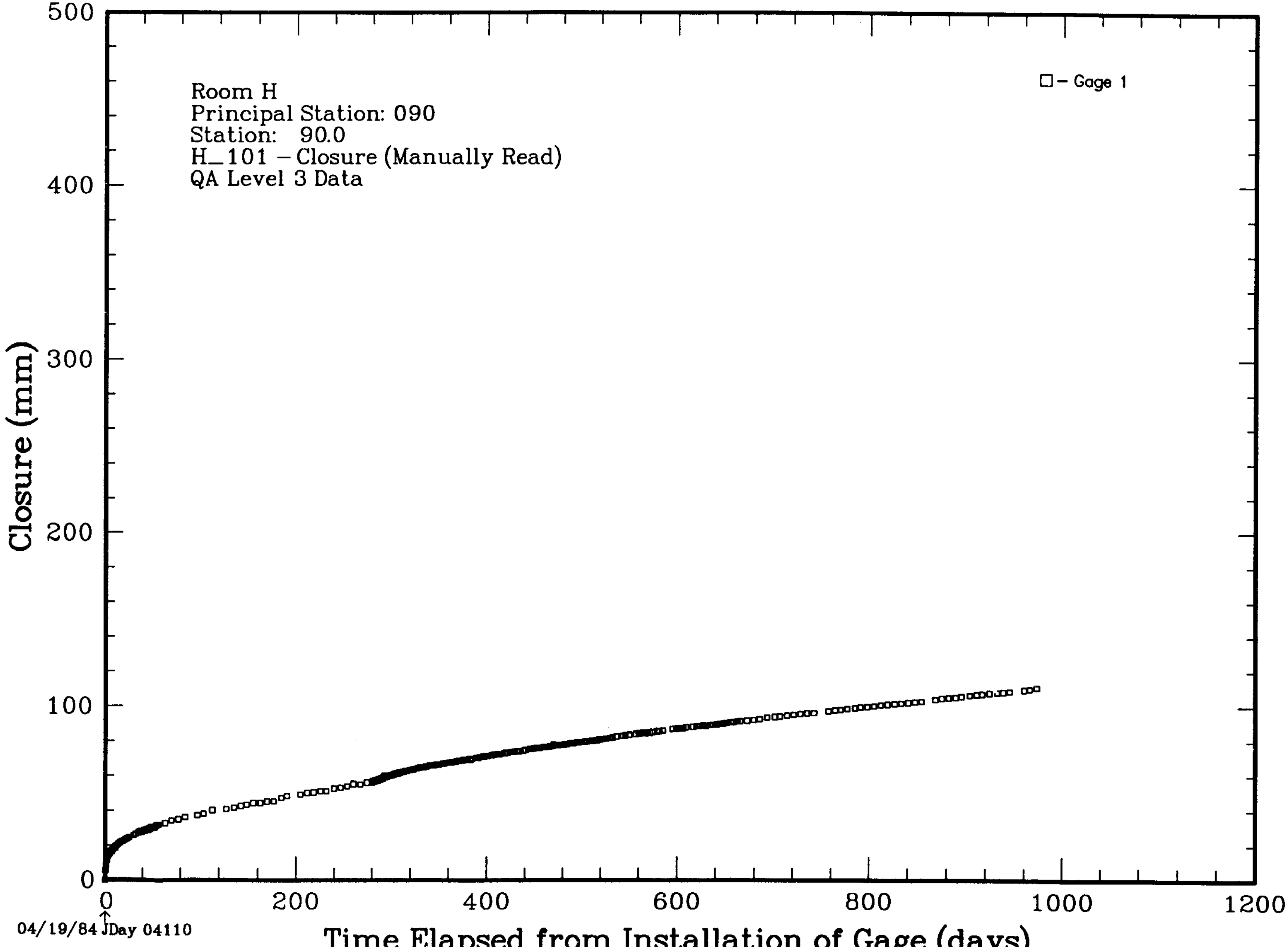

Figure 5.1.1a. Early Room Entry Closure Gages, H 101

Table 5.1.1b. Early Room Entry Closure Gages, H 102

Gage: H_102

****

***** H_102 PI Comments *****

11/24.87 RLJ [96%] THE DATA ARE OUTSTANDING. THIS GAGE IS INITIALLY IN THE ROOM H ACCESS DRIFT, BUT ALSO LOCATED SUCH THAT IT IS EVENTUALLY AT THE MIDSPAN OF THE ROOM EXCAVATION. UP TO DAY 283 IT MEASURED JUST THE RESPONSE OF THE ROOM ACCESS DRIFT. AFTER DAY 283 WHEN MINING OF THE ROOM H PROPER STARTED, IT MEASURED THE DISPLACEMENTS INDUCED BY THE MINING OF THE ROOM. (DEM)

***** H_102 Location *****

Principal Station 090
Station 89.7

Gage Number	Gage Type	Rec	Dir	Gage Coordinates				Prin Stat		Room		Gage Manuf	Inst Date	PO Item	Comments
				R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)				
H_102-1	CONV T	MAN	V	11.04	11.03	89.65	89.70	-1.56	1.56	-1.48	1.64	SNL	04/21/84	T91025-000	

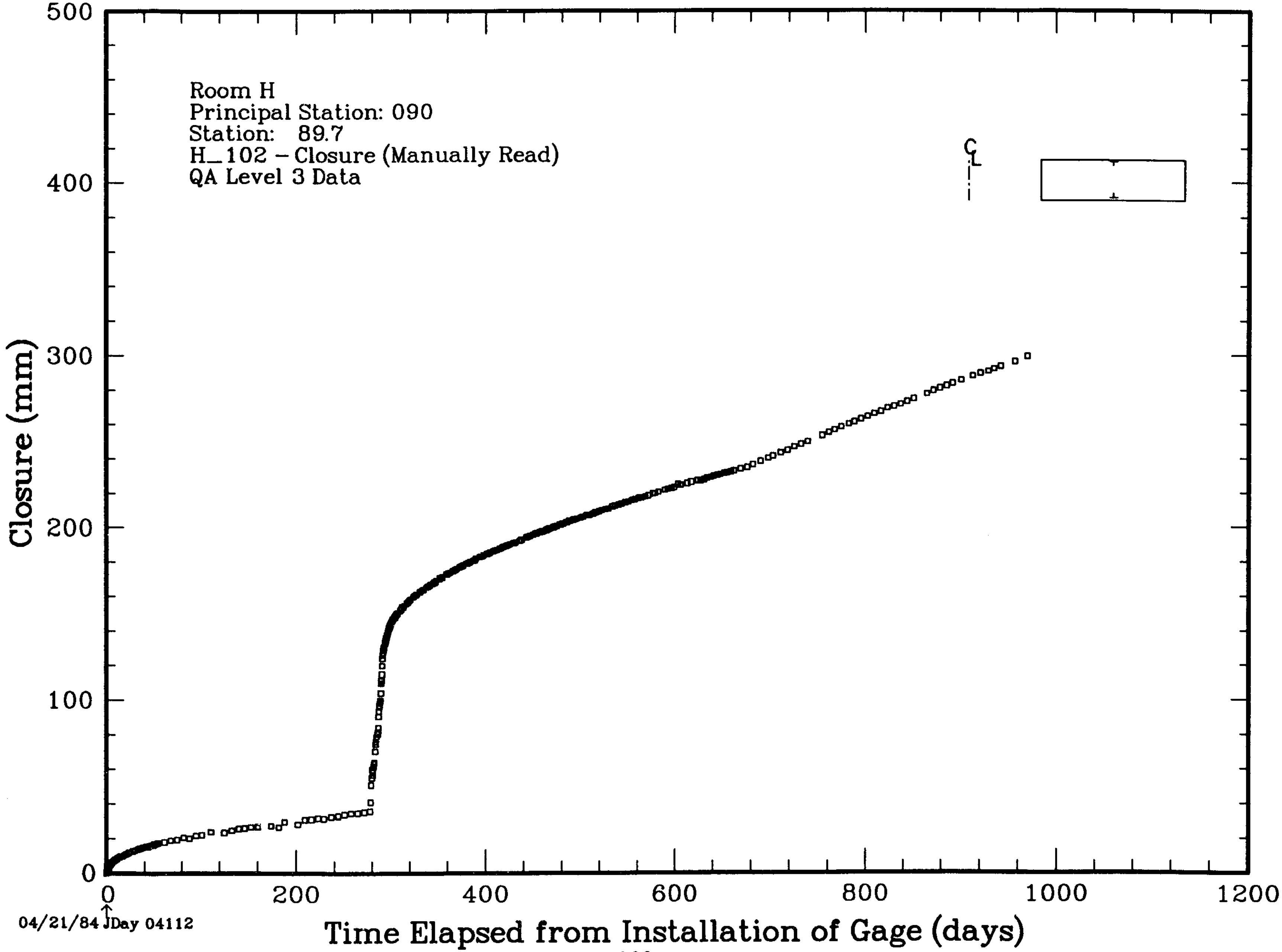

Figure 5.1.1b. Early Room Entry Closure Gages, H 102

Table 5.1.1c. Early Room Entry Closure Gages, H 103

Gage: H_103

****

***** H_103 PI Comments *****

11/24/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS GAGE IS INITIALLY IN THE ROOM H ACCESS DRIFT, BUT ALSO LOCATED SUCH THAT IT IS EVENTUALLY AT THE PILLAR SIDE, AND TO A GOOD APPROXIMATION MEASURES PILLAR SHORTENING. UP TO DAY 283 IT MEASURED THE CLOSURE AT THE BLIND END OF THE DRIFT OR DRIFT FACE. AFTER DAY 283 IT MEASURED THE DEFORMATION IN THE OUTER FIBERS OF THE PILLAR, PILLAR SHORTENING, DURING AND AFTER THE EXCAVATION OF THE ROOM PROPER. (DEM)

***** H_103 Location *****

Principal Station 090
Station 89.1

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_103-1	CONV	T MAN	V	6.16	6.17	89.06	89.32	-1.51	1.68	-1.44	1.76	SNL	04/21/84	T91025-000	

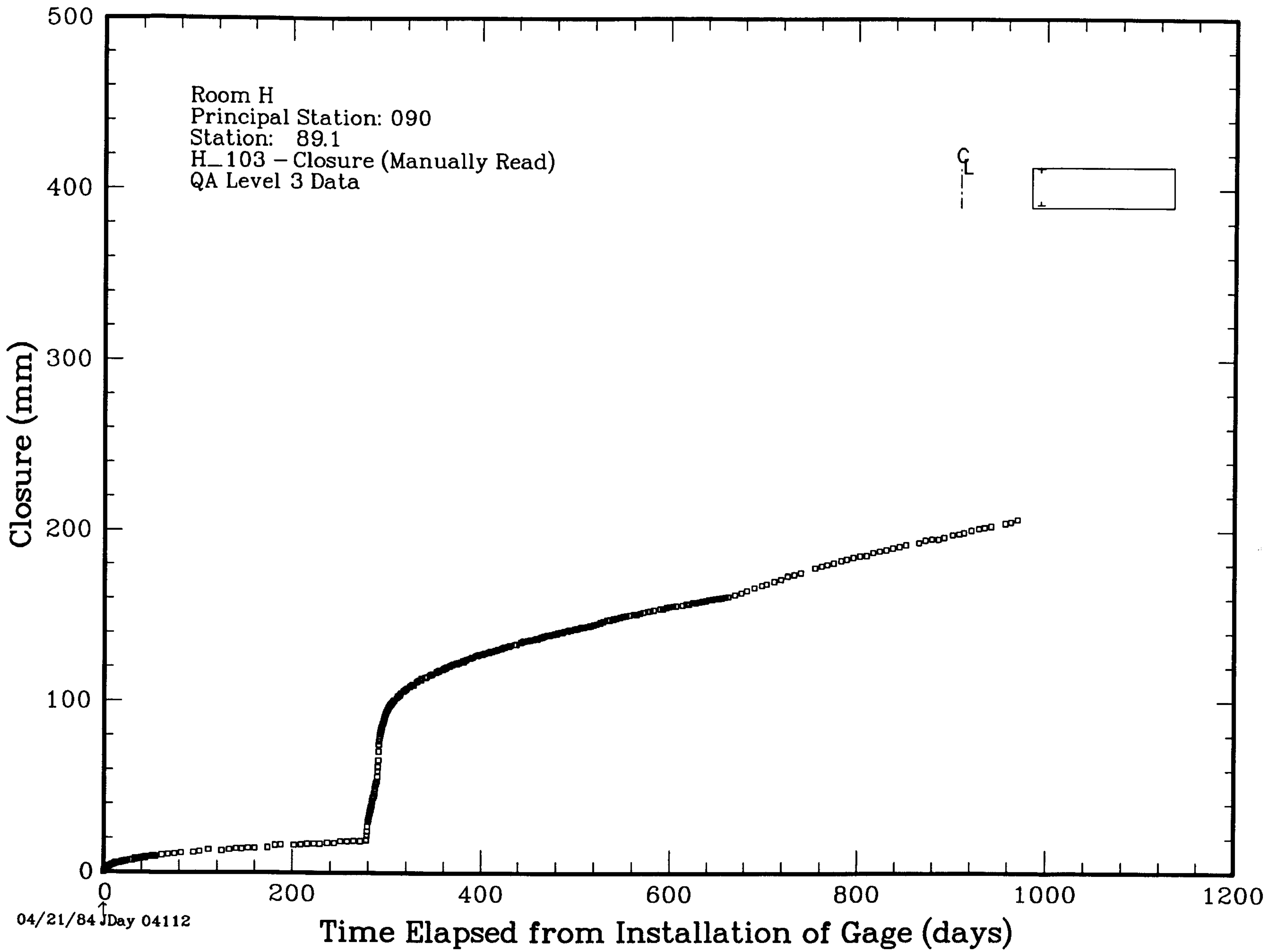

Figure 5.1.1c. Early Room Entry Closure Gages, H 103

Table 5.1.2a. Early Pillar Extensometer Gages, H 317

Gage: H_317

****

***** H_317 PI Comments *****

08/14/87 DLH:DEM [RANK = 8(1'),6(1),7(2),7(3),8(4),8(5),8(6)] THIS UNIT IS UNUSUAL BECAUSE IT WAS INSTALLED FROM THE ENTRY DRIFT INTO WHAT WOULD BECOME THE PILLAR. WHEN THE PILLAR WAS EXCAVATED, ABOUT 220 DAYS AFTER THE UNIT WAS ACTIVATED, THE GAGE 1' ANCHOR WHICH WAS APPROXIMATELY AT 180 DEGREES AND AT 11 METERS RADIUS (MIDROOM LOCATION - IN THE CARTOON THIS ANCHOR IS AT AN INITIAL DEPTH OF 16.5 M FROM THE COLLAR) WAS MINED OUT AND THE RECORD WAS TERMINATED. THE SAME INSTRUMENT CHANNEL WAS REACTIVATED ABOUT 48 DAYS LATER AS GAGE 1 BY INSTALLING A NEW ANCHOR AT THE PILLAR SURFACE WHICH WAS APPROXIMATELY AT 180 DEGREES AND 5.5 METERS RADIUS (IN THE CARTOON THIS ANCHOR IS SHOWN AT A DEPTH OF 11.0 M FROM THE COLLAR). THE RANKING OF 6 FOR GAGE 1 IS A CONSEQUENCE OF THE NEED TO ADJUST THE ORIGINAL DISPLACEMENT ACCORDING TO OTHER INFORMATION. THE ACTUAL DATA QUALITY, EXCLUSIVE OF THE ADJUSTMENT OF GAGE 1, IS GENERALLY EXCELLENT; HOWEVER, GAGES 1, 2 AND 3 HAVE EXTENSIVE DELETIONS AT LATE TIMES AS A RESULT OF POSSIBLE WIRE CLAMPING DUE TO HOLE CLOSURE, WHICH EVENTUALLY RECOVERED NATURALLY OR BY MAINTENANCE ACTIONS. GAGE 1 DATA WERE DELETED AFTER DAY 633, GAGE 2 DATA WERE DELETED BETWEEN DAY 633 AND 664 AND ALSO BETWEEN 800 AND 900, AND GAGE 3 DATA WERE DELETED BETWEEN DAY 790 AND 995. [COMPRESSION = 3.77:1] (DEM)

IT MUST BE NOTED THAT THE DISPLACEMENT POSITION OF GAGE 1 IS STILL APPROXIMATE BECAUSE ENOUGH ANALYSIS OF OTHER DATA HAS NOT BEEN DONE TO PERMIT GOOD EXTRAPOLATIONS TO BE MADE TO LOCATE THE DISPLACEMENT ACCURATELY. DATA OF GAGE 1 SHOULD BE USED WITH CAUTION. (DEM)

***** H_317 Location *****

Principal Station 090
Station 89.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_317-1	EXT	T REM	H	5.56	-5.42	89.81	90.06	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-2	EXT	T REM	H	5.56	-4.02	89.81	90.09	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-3	EXT	T REM	H	5.56	-2.67	89.81	90.20	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-4	EXT	T REM	H	5.56	0.07	89.81	80.34	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-5	EXT	T REM	H	5.56	2.82	89.81	89.69	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-6	EXT	T REM	H	5.56	4.21	89.81	89.75	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	

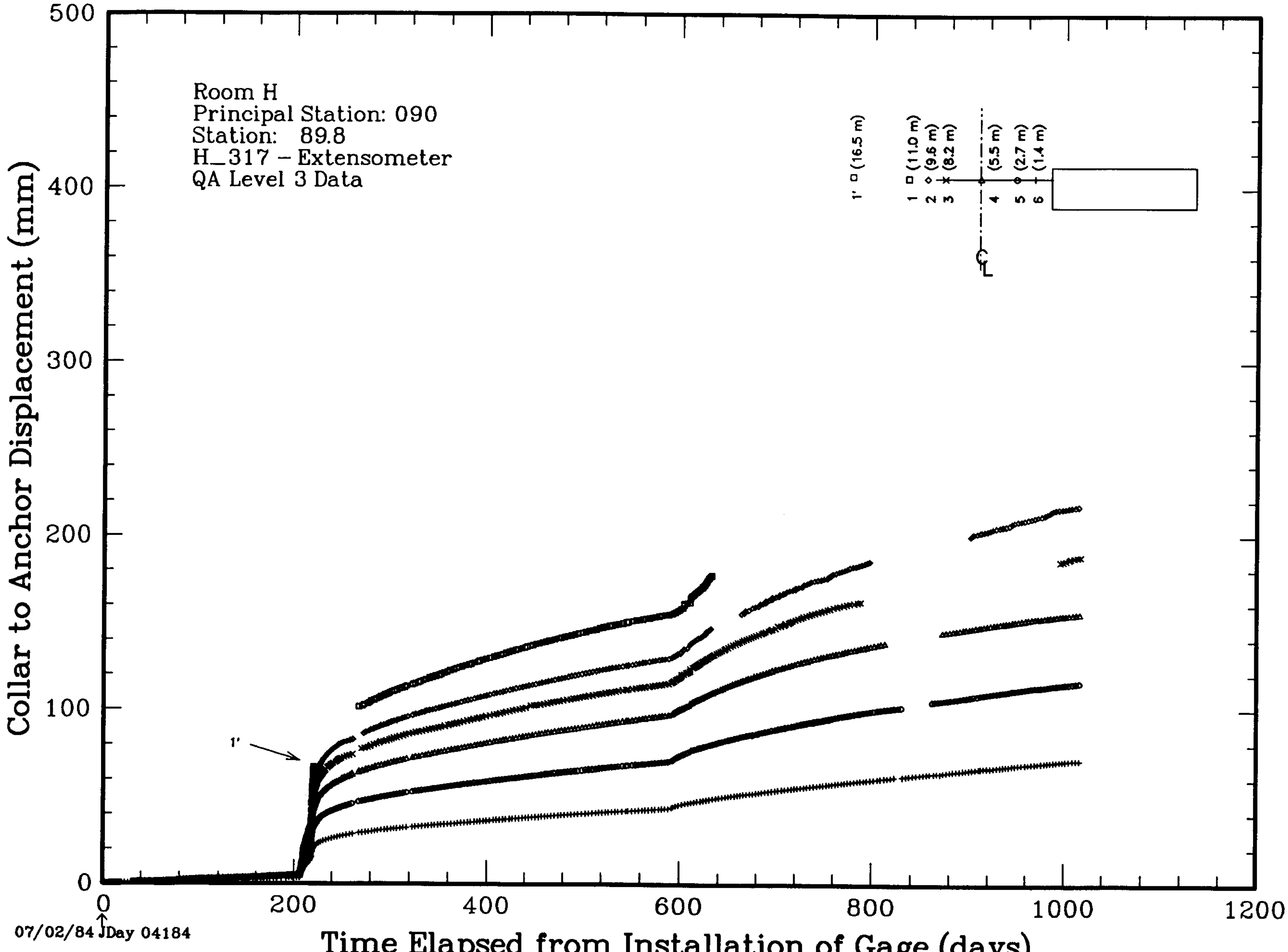

Figure 5.1.2a. Early Pillar Extensometer Gages, H 317

Table 5.1.3a. Early Pillar Stress Meters, H 549

Gage: H_549

****

***** H_549 PI Comments *****

09/23/87 DLH:DEM [RANK = 10(10,10(2),10(3)] THIS UNIT WAS ONE OF THOSE EMPLACED IN THE PILLAR MATERIAL PRIOR TO EXCAVATION OF THE H ROOM. THE SLOW CHANGES OF STRESS AROUND THE ROOM H ENTRY IS APPARENT, AS IS THE SUDDEN CHANGE OF STRESS WHEN THE ROOM H WAS EXCAVATED BEGINNING ON DAY 206 (JDAY 5024) AND ENDING ON DAY 237 (JDAY 5055). THE DATA COME TO A NEW PLATEAU, MAINTAINED FOR SOME PERIOD OF TIME. EVENTUALLY THE DATA SHOW A DECLINE IN STRESS OR AN ERRATIC RESPONSE. THIS CAUSED GAGE 1 TO BE DISCONTINUED FROM REMOTE RECORDING ON DAY 413, GAGE 2 TO SHOW A STRESS DECLINE BEGINNING WITH DAY 500, AND GAGE 3 TO DEVELOP ERRATIC RESPONSE BEGINNING ON DAY 515. [COMPRESSION = 1.81:1] (DEM)

***** H_549 Location *****

Principal Station 090
Station 92.8

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_549-1	STR	T REM	H	5.73	-1.59	92.84	94.84	-0.56	-0.50	-0.48	-0.42	SPCL.EN	06/27/84	58-0489#01	X-0.499Y-0.049Z+0.866
H_549-2	STR	T REM	H	5.73	-1.29	92.84	95.03	-0.56	-0.50	-0.48	-0.42	SPCL.EN	06/27/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_549-3	STR	T REM	H	5.73	-0.98	92.84	95.70	-0.56	-0.51	-0.48	-0.43	SPCL.EN	06/27/84	58-0489#01	X+0.499Y+0.049Z+0.866

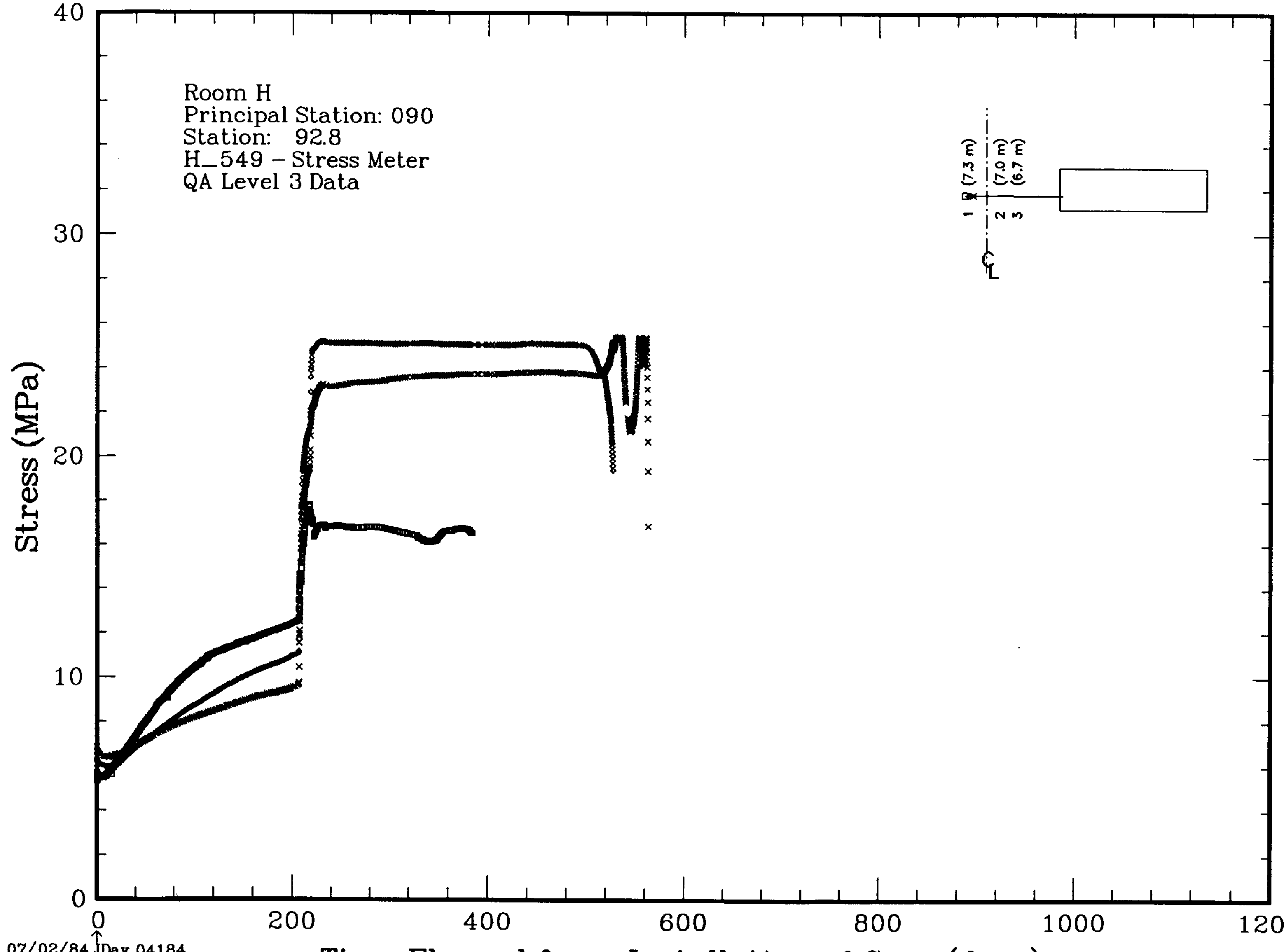

Figure 5.1.3a. Early Pillar Stress Meters, H 549

Table 5.1.3b. Early Pillar Stress Meters, H 550

Gage: H_550

****

***** H_550 PI Comments *****

09/23/87 DLH:DEM [RANK = 9(1),8(2),9(3)] THIS UNIT WAS ONE OF THOSE EMPLACED IN THE PILLAR MATERIAL PRIOR TO EXCAVATION OF THE H ROOM. THE DATA SHOW THE GRADUAL CHANGES RESULTING FROM THE STRESS FIELD AROUND THE ROOM H ENTRY AND THEN THE MARKED CHANGES RESULTING FROM THE EXCAVATION OF THE H ROOM. ROOM EXCAVATION STARTED ON DAY 207 (JDAY 5024) AND ENDED ON DAY 237 (JDAY 5055). THE DATA QUALITY, WHILE EITHER EXCELLENT OR EXCEPTIONAL, SHOW A LOSS OF STRESS QUITE SOON AFTER THE MINING OF THE ROOM. BOTH GAGE 1 AND 3 SHOW A PLATEAU BEFORE THE LOSS OF STRESS; HOWEVER, GAGE 2 MAY NOT BE AT A PLATEAU. GAGE 1 WAS DISCONTINUED FROM REMOTE RECORDING ON DAY 396, GAGE 2 ON DAY 364, AND GAGE 3 ALSO ON DAY 364. [COMPRESSION = 1.21:1] (DEM)

***** H_550 Location *****

Principal Station 090
Station 86.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_550-1	STR	T REM	H	5.73	0.85	86.89	92.25	-0.58	-0.66	-0.50	-0.58	SPCL.EN	06/28/84	58-0489#01	X-0.499Y+0.054Z+0.866
H_550-2	STR	T REM	H	5.73	1.16	86.89	90.60	-0.58	-0.65	-0.50	-0.57	SPCL.EN	06/28/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_550-3	STR	T REM	H	5.73	1.46	86.89	89.52	-0.58	-0.65	-0.50	-0.57	SPCL.EN	06/28/84	58-0489#01	X+0.499Y-0.054Z+0.866

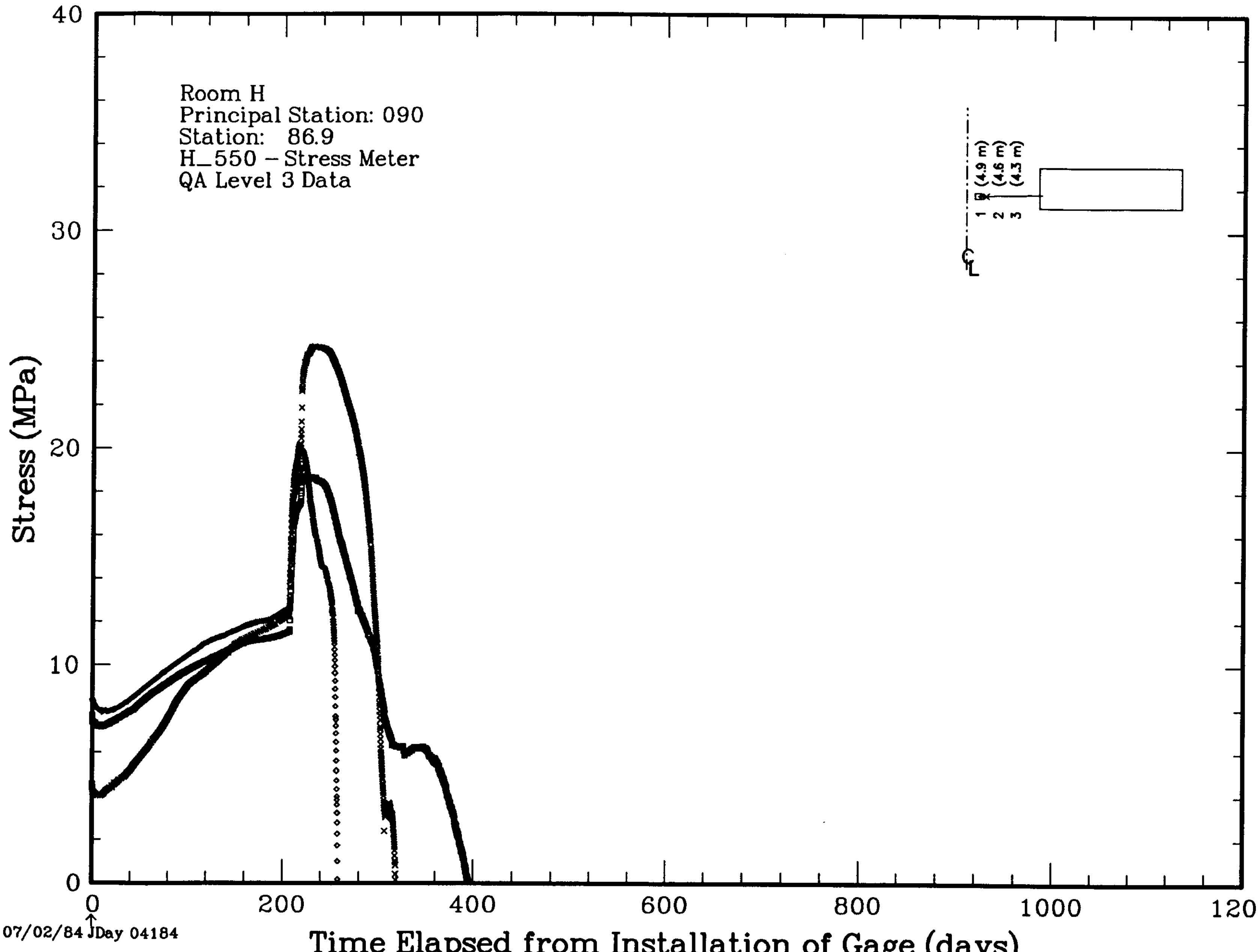

Figure 5.1.3b. Early Pillar Stress Meters, H 550

Table 5.1.3c. Early Pillar Stress Meters, H 551

Gage: H_551

****

***** H_551 PI Comments *****

09/23/87 DLH:DEM [RANK = 10(1),10(2),10(3)] THIS UNIT IS ONE OF THOSE EMPLACED IN THE MILLAR MATERIAL PRIOR TO THE EXCAVATION OF ROOM H. THE GRADUAL INCREASE IN STRESS IS THE RESPONSE TO THE ROOM H ENTRY STRESS FIELD. EXCAVATION OF THE ROOM H CAUSED THE ABRUPT INCREASE IN THE STRESS RESPONSE OF THE GAGES, WITH EXCAVATION STARTING ON DAY 206 (JDAY 5024) AND ENDING ON DAY 237 (JDAY 5055). DECREASES IN THE STRESS OF GAGE 1 BEGAN ON DAY 251, GAGE 2 ON DAY 350, AND GAGE 3 ON ABOUT DAY 597. FOR GAGE 3 THE STRESS DETERIORATION STARTED SHORTLY AFTER THE TURN-ON OF THE HEATERS ON DAY 592 (JDAY 6044). THE DATA QUALITY OF THE UNIT IS OUTSTANDING, AND IS MARRED ONLY BY THE LOSS OF STRESS IN THE GAGES. [COMPRESSION 1.84:1] (DEM)

***** H_551 Location *****

Principal Station 090
Station 89.7

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_551-1	STR	T REM	H	5.71	3.27	89.69	90.11	-0.55	-0.56	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X-0.500Y+0.005Z+0.866
H_551-2	STR	T REM	H	5.71	3.58	89.69	90.00	-0.55	-0.56	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_551-3	STR	T REM	H	5.71	3.88	89.69	89.96	-0.55	-0.55	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X+0.500Y-0.005Z+0.866

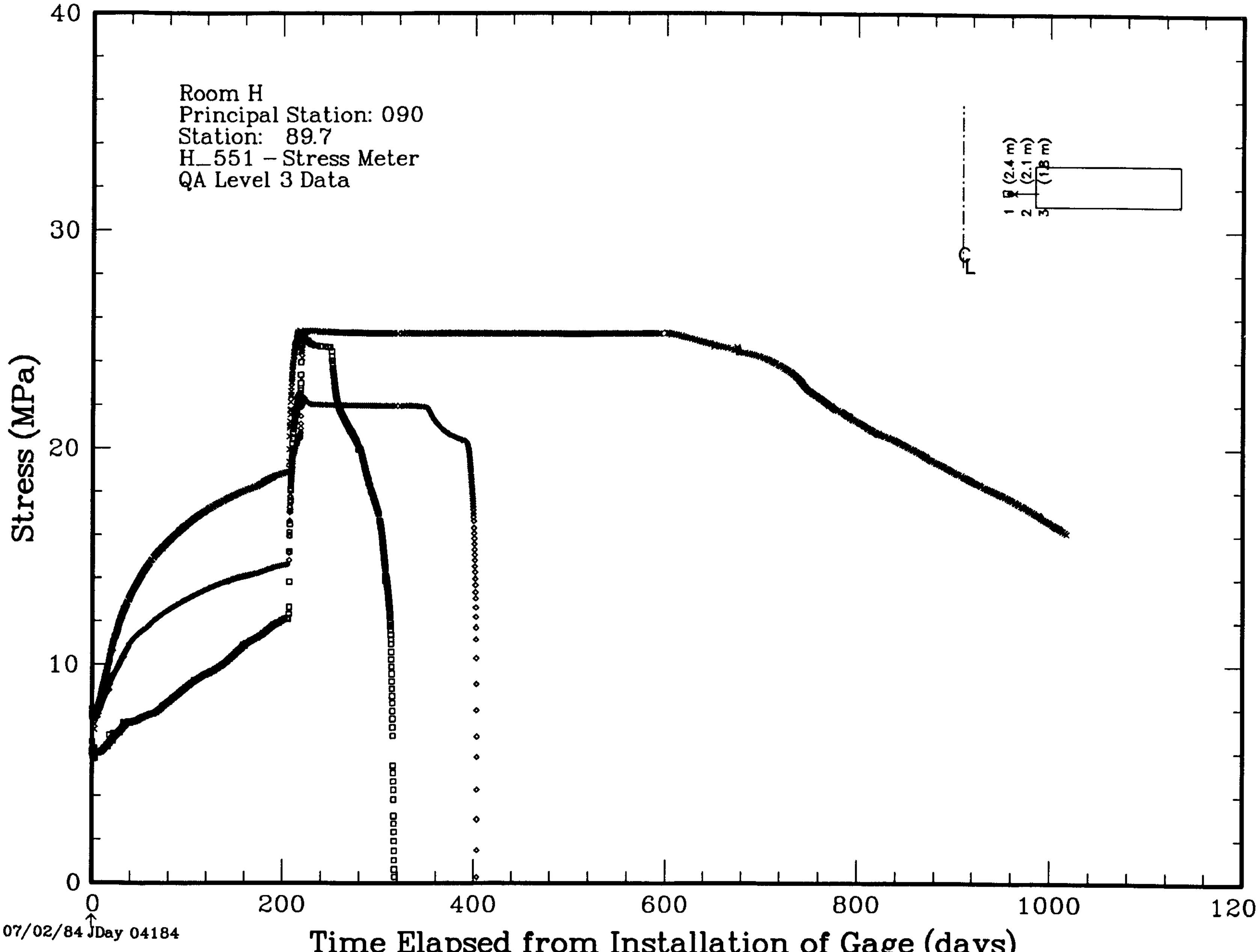

Figure 5.1.3c. Early Pillar Stress Meters, H 551

Table 5.1.4a. Early Room Entry Thermocouple, H 701

Gage: H_701

****

***** H_701 PI Comments *****

08/16/87 DLH [RANK = 8(1)] MINOR AMOUNTS OF SCATTERED DATA FROM A RESISTANCE SHORT WERE DELETED; BETTER THAN 95% OF THE DATA ARE EXCELLENT. THE DATA DO HAVE AN UNACCOUNTED FOR RESIDUAL SCATTER OF ABOUT +/- 0.2 DEGREES; THIS IS ACCEPTABLE. [COMPRESSION 5.54:1] (DEM)

***** H_701 Location *****

Principal Station 090
Station 92.1

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_701-1	TC	P REM	H	46.00	49.00	92.14	110.25	0.09	-0.05	0.94	0.79	ARI	06/10/85	65-2785#09	

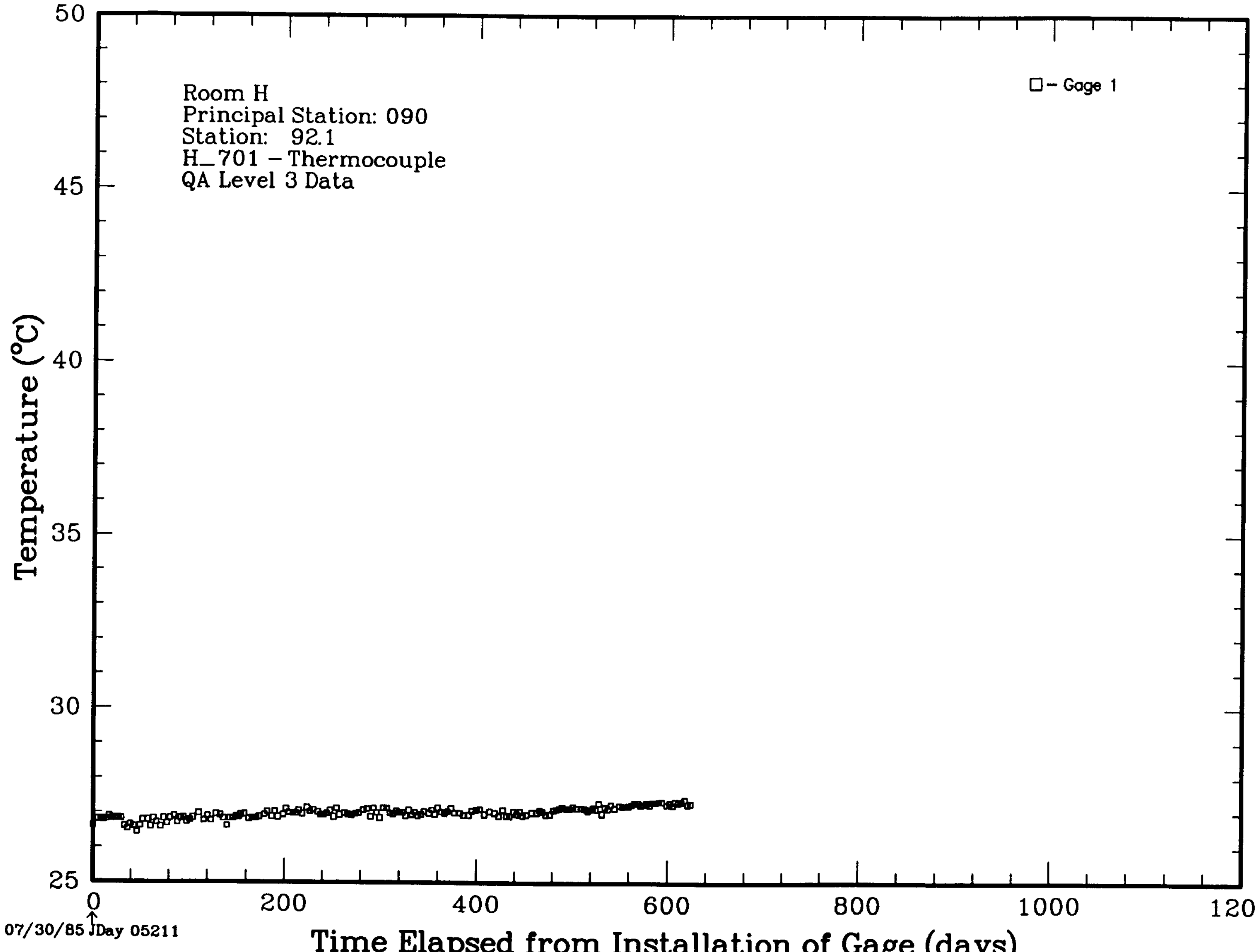

Figure 5.1.4a. Early Room Entry Thermocouple, H 701

5.2 Manual and Remote Closure Measurements

A guide to the location of all temporary and permanent closure units (gages) installed in Room H is given in Table 5.2.1. The table presents schematically the relative gage positions at the principal stations of the room. In general, the gage numbers of logical collections of gages are in sequence. H 101, H 102, and H 103 are all vertical gages measuring early room entry closure. H 104 through H 111 are all vertical gages measuring displacements adjacent to the pillar or rib surfaces. Vertical closures at room midspan are measured then by H 120 through H 123 and H 201 through H 204. And finally, horizontal closures at room midheight are measured by H 124 through H 127 and H 205 through H 208.

Manual closure data are given in Tables 5.2.1a-s and Figures 5.2.1a-s, and remote closure data in Tables 5.2.2a-h and Figures 5.2.2a-h.

Closure gages measure the surface displacements of the underground excavations or openings. These measurements are crucial because they give the integrated effect of the creep displacements in the salt around the excavation. Moreover, closure measurement gages can be installed soon after completion of excavation, which was the case in Room H. The first three gages (H 101, H 102 and H 103) were initially temporary gages installed in the room entry to obtain vertical displacements. These gages monitored the displacements of the entry for about a year before the room was excavated. Comparison of H 103 (at the drift blind end) and H 102 (at some distance from the blind end) show the influence of the drift face in decreasing the measured displacements. Also, the greater displacement measured at H 101 compared to that measured at H 102 can be perhaps interpreted as the influence of the subentry drifts to the north.

All the manual closure data are remarkably consistent at all the principal stations around the room. In fact, the vertical midspan and horizontal midheight manual and remote measurements agree exceptionally well over their common time intervals.

Of special interest in the manual closure records is the comparison between the vertical measurements at the pillar surface (pillar shortening), room midspan, and rib surface (rib shortening). See, for example, the results of gages H 104 (pillar surface) in Figure 5.2.1d, H 120 (room midspan) in Figure 5.2.1l, and H 105 (rib surface) in Figure 5.2.1e. These measurements, of course, do not include all the closure displacements because of the delay in installation. However, the measurements do indicate that the room midspan closure over the time frame of the measurements is nearly 40% greater than the pillar shortening, and 70% greater than the rib shortening. The influence of temperature on the shortening is much more pronounced at the pillar than the rib. To give correct percentage differences between the room midspan closures and the pillar surface and rib surface closures requires more extensive analysis and the use of appropriate procedures for reconstruction of time related gage emplacements to obtain total displacements. These procedures are discussed in the interpretative aids section of the report (Section 6.0).

Vertical and horizontal measurements of closure, as expected, show a marked increase with the beginning of pillar heating. The pronounced increase in horizontal closure is primarily due to the increased pillar deformation and thermal expansion, with little contribution from the rib. Correctly decomposing the contributions of the pillar and the rib to the horizontal closure will require numerical calculations.

Table 5.2.1 Closure Units (Gages) Location Guide

Station	Direction		Relative Location: pillar	center		rib (entry)
H ST090	Vertical	roof	H 103	H 102		H 101
	Horizontal	mid				
	Vertical	floor	*	*		*
H ST135	Vertical	roof	H 104	H 120	H 105	
	Horizontal	mid	H 124		*	
	Vertical	floor	*	*	*	
H ST225	Vertical	roof	H 106	H 121	H 107	
	Horizontal	mid	H 125		*	
	Vertical	floor	*	*	*	
H ST315	Vertical	roof	H 108	H 122	H 109	
	Horizontal	mid	H 126		*	
	Vertical	floor	*	*	*	
H ST045	Vertical	roof	H 110	H 123	H 111	
	Horizontal	mid	H 127		*	
	Vertical	floor	*	*	*	
H ST135	Vertical	roof		H 201		
	Horizontal	mid	H 205		*	
	Vertical	floor		*		
H ST225	Vertical	roof		H 202		
	Horizontal	mid	H 206		*	
	Vertical	floor		*		
H ST315	Vertical	roof		H 203		
	Horizontal	mid	H 207		*	
	Vertical	floor		*		
H ST045	Vertical	roof		H 204		
	Horizontal	mid	H 208		*	
	Vertical	floor		*		

Remote closure measurements, as in the case of the comparable manual measurements, show almost identical responses regardless of the principal station where they were taken. A comparison of H 202 (Figure 5.2.2b) and H 203 (Figure 5.2.2c) data, the most distant from the room entry, shows absolutely no difference in response. However, very slight differences in response can be seen when these records are compared to the measurements of gages H 201 and H 204 (Figures 5.2.2a and 5.2.2d) located nearer to the room entry, which are themselves almost but not quite identical. Whether or not the differences are due to the perturbation of the entry drift is not yet known. Similar small differences are noticed in the remote horizontal closures.

With the explanations just presented, the manual and remote closure data in the following tables and graphs should be fairly straightforward.

Table 5.2.1a. Manual Closure Gage, H 101

Gage: H_101

****

***** H_101 PI Comments *****

11/23/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS GAGE IS APPROXIMATELY IN THE MIDDLE OF THE ROOM H ACCESS DRIFT. UP TO DAY 283 IT IS MEASURING JUST THE RESPONSE OF THE ROOM ACCESS DRIFT. AFTER DAY 283 WHEN MINING OF THE ROOM H PROPER STARTED, IT IS MEASURING NOT ONLY ITS OWN DISPLACEMENTS BUT ALSO THOSE INDUCED BY THE MINING OF THE ROOM. (DEM)

***** H_101 Location *****

Principal Station 090
Station 90.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_101-1	CONV T	MAN	V	45.99	45.95	89.96	89.94	-1.53	1.53	-0.69	2.38	SNL	04/19/84	T91025-000	

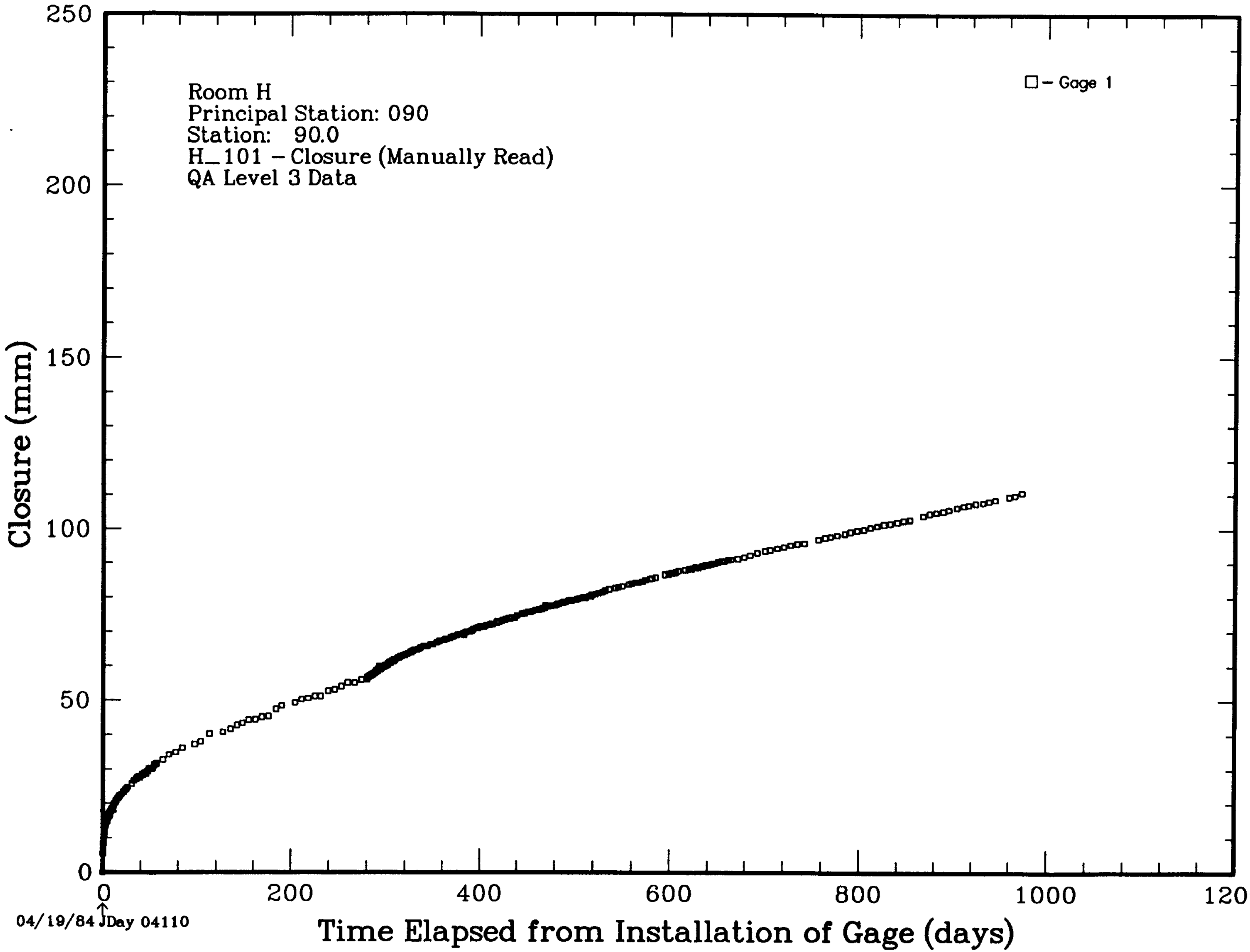

Figure 5.2.1a. Manual Closure Gage, H 101

Table 5.2.1b. Manual Closure Gage, H 102

Gage: H_102

****

***** H_102 PI Comments *****

11/24.87 RLJ [96%] THE DATA ARE OUTSTANDING. THIS GAGE IS INITIALLY IN THE ROOM H ACCESS DRIFT, BUT ALSO LOCATED SUCH THAT IT IS EVENTUALLY AT THE MIDSPAN OF THE ROOM EXCAVATION. UP TO DAY 283 IT MEASURED JUST THE RESPONSE OF THE ROOM ACCESS DRIFT. AFTER DAY 283 WHEN MINING OF THE ROOM H PROPER STARTED, IT MEASURED THE DISPLACEMENTS INDUCED BY THE MINING OF THE ROOM. (DEM)

***** H_102 Location *****

Principal Station 090
Station 89.7

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_102-1	CONV T	MAN	V	11.04	11.03	89.65	89.70	-1.56	1.56	-1.48	1.64	SNL	04/21/84	T91025-000	

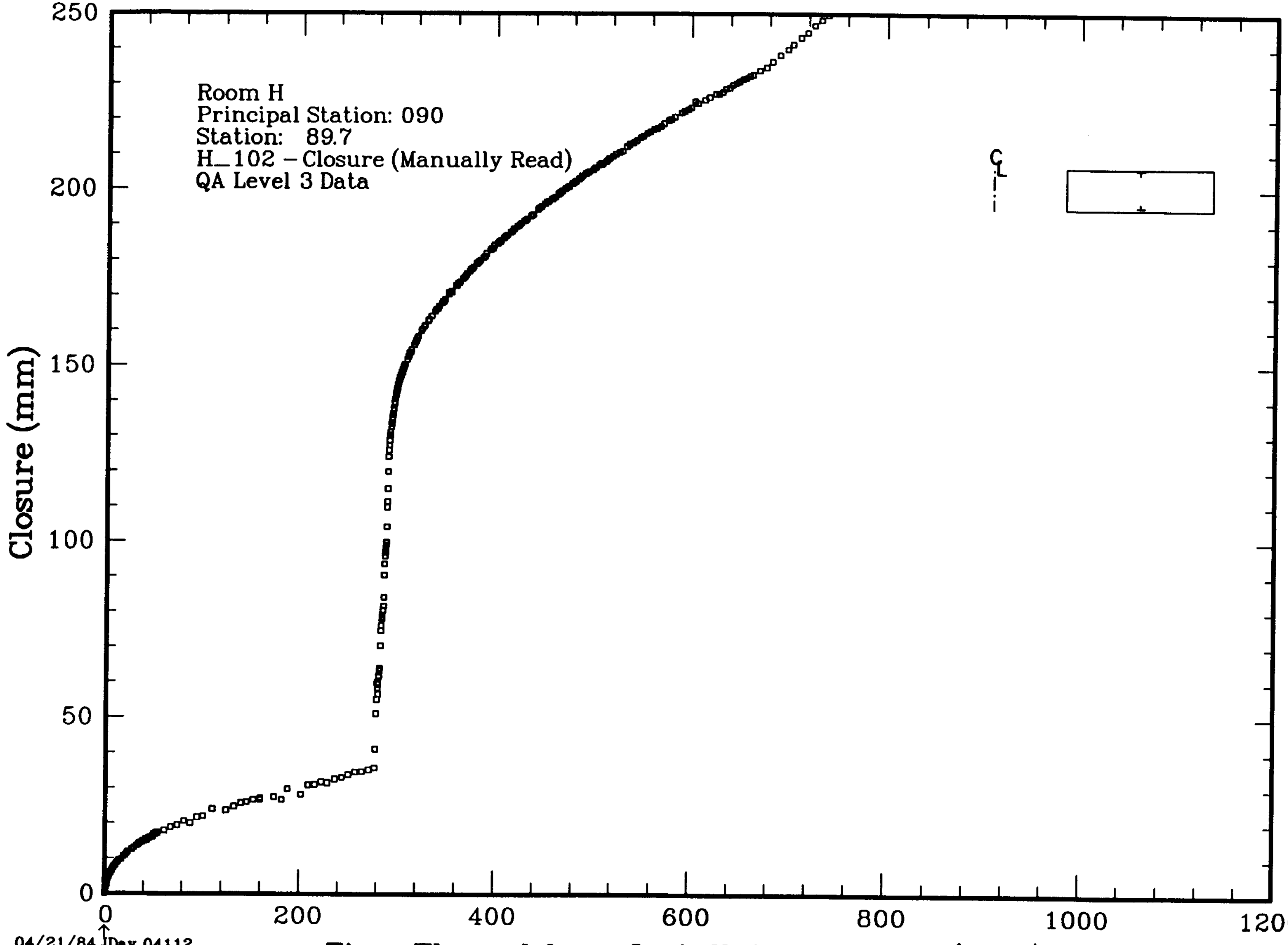

Figure 5.2.1b. Manual Closure Gage, H 102

Table 5.2.1c. Manual Closure Gage, H 103

Gage: H_103

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***** H_103 PI Comments *****

11/24/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS GAGE IS INITIALLY IN THE ROOM H ACCESS DRIFT, BUT ALSO LOCATED SUCH THAT IT IS EVENTUALLY AT THE PILLAR SIDE, AND TO A GOOD APPROXIMATION MEASURES PILLAR SHORTENING. UP TO DAY 283 IT MEASURED THE CLOSURE AT THE BLIND END OF THE DRIFT OR DRIFT FACE. AFTER DAY 283 IT MEASURED THE DEFORMATION IN THE OUTER FIBERS OF THE PILLAR, PILLAR SHORTENING, DURING AND AFTER THE EXCAVATION OF THE ROOM PROPER. (DEM)

***** H_103 Location *****

Principal Station 090
Station 89.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_103-1	CONV T	MAN	V	6.16	6.17	89.06	89.32	-1.51	1.68	-1.44	1.76	SNL	04/21/84	T91025-000	

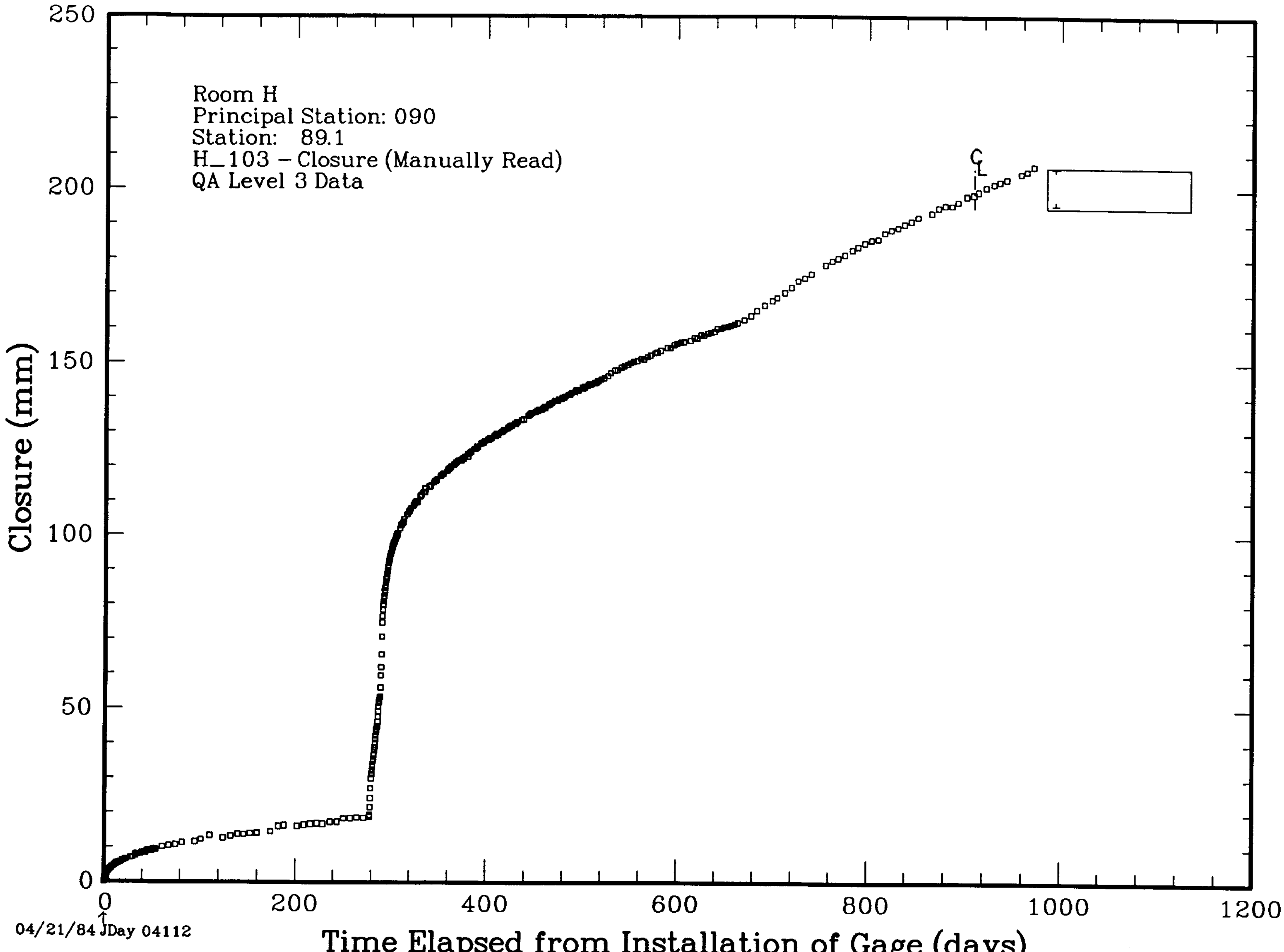

Figure 5.2.1c. Manual Closure Gage, H 103

Table 5.2.1d. Manual Closure Gage, H 104

Gage: H_104

****

***** H_104 PI Comments *****

11/24/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF ROOM H EXCAVATION, AND MEASURES TO A GOOD APPROXIMATION THE PILLAR SHORTENING FROM THAT TIME. (DEM)

***** H_104 Location *****

Principal Station 135
Station 137.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_104-1	CONV P	MAN	V	5.77	5.77	137.75	137.71	-0.94	1.56	-0.83	1.66	SNL	02/25/85	T91025-000	

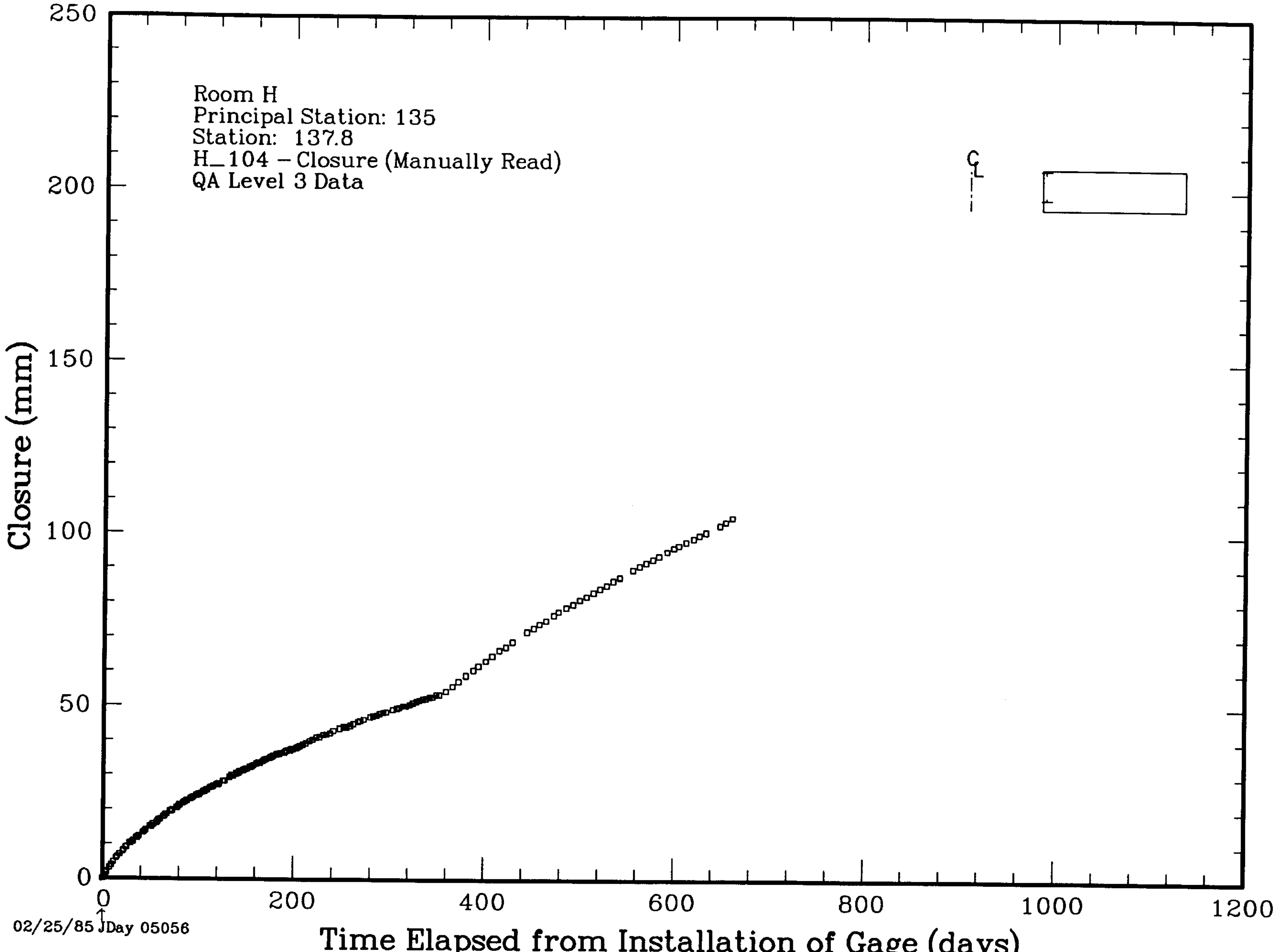

Figure 5.2.1d. Manual Closure Gage, H 104

Table 5.2.1e. Manual Closure Gage, H 105

Gage: H_105

****

***** H_105 PI Comments *****

11/24/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF ROOM H EXCAVATION, AND MEASURES TO A GOOD APPROXIMATION THE RIB SHORTENING FROM THAT TIME. (DEM)

***** H_105 Location *****

Principal Station 135
Station 137.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_105-1	CONV	P MAN	V	16.14	16.13	137.95	137.90	-1.56	1.52	-1.46	1.62	SNL	02/25/85	T91025-000	

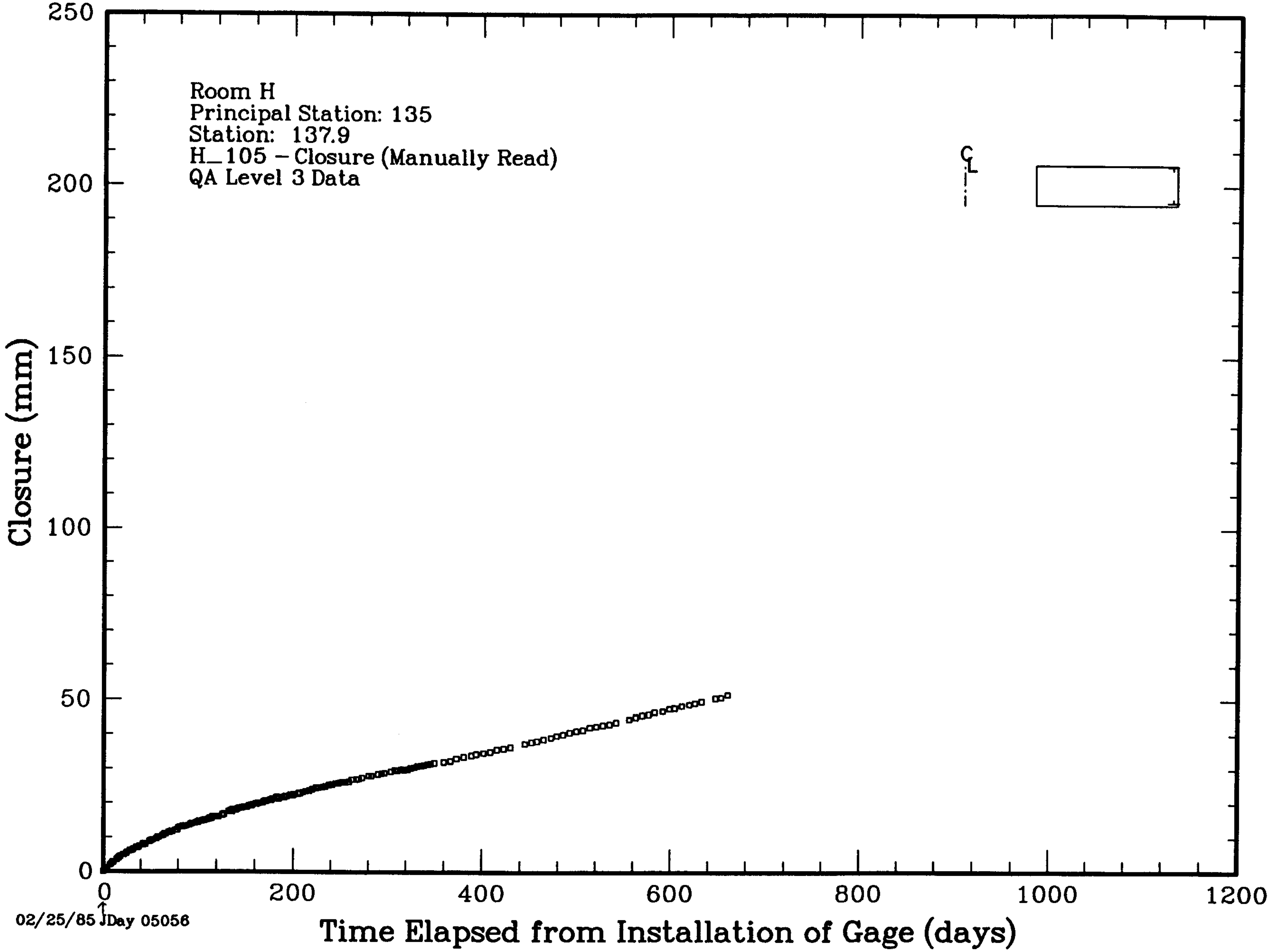

Figure 5.2.1e. Manual Closure Gage, H 105

Table 5.2.1f. Manual Closure Gage, H 106

Gage: H_106

****

***** H_106 PI Comments *****

11/24/87 RLJ [99%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF ROOM H EXCAVATION. IT IS LOCATED NEXT TO THE PILLAR SURFACE AND MEASURES, TO A GOOD APPROXIMATION, PILLAR SHORTING FROM THE TIME OF INSTALLATION. (DEM)

***** H_106 Location *****

Principal Station 225
Station 228.3

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_106-1	CONV P	MAN	V	5.80	5.78	228.31	228.17	-1.56	1.53	-1.65	1.44	SNL	02/25/85	T91025-000	

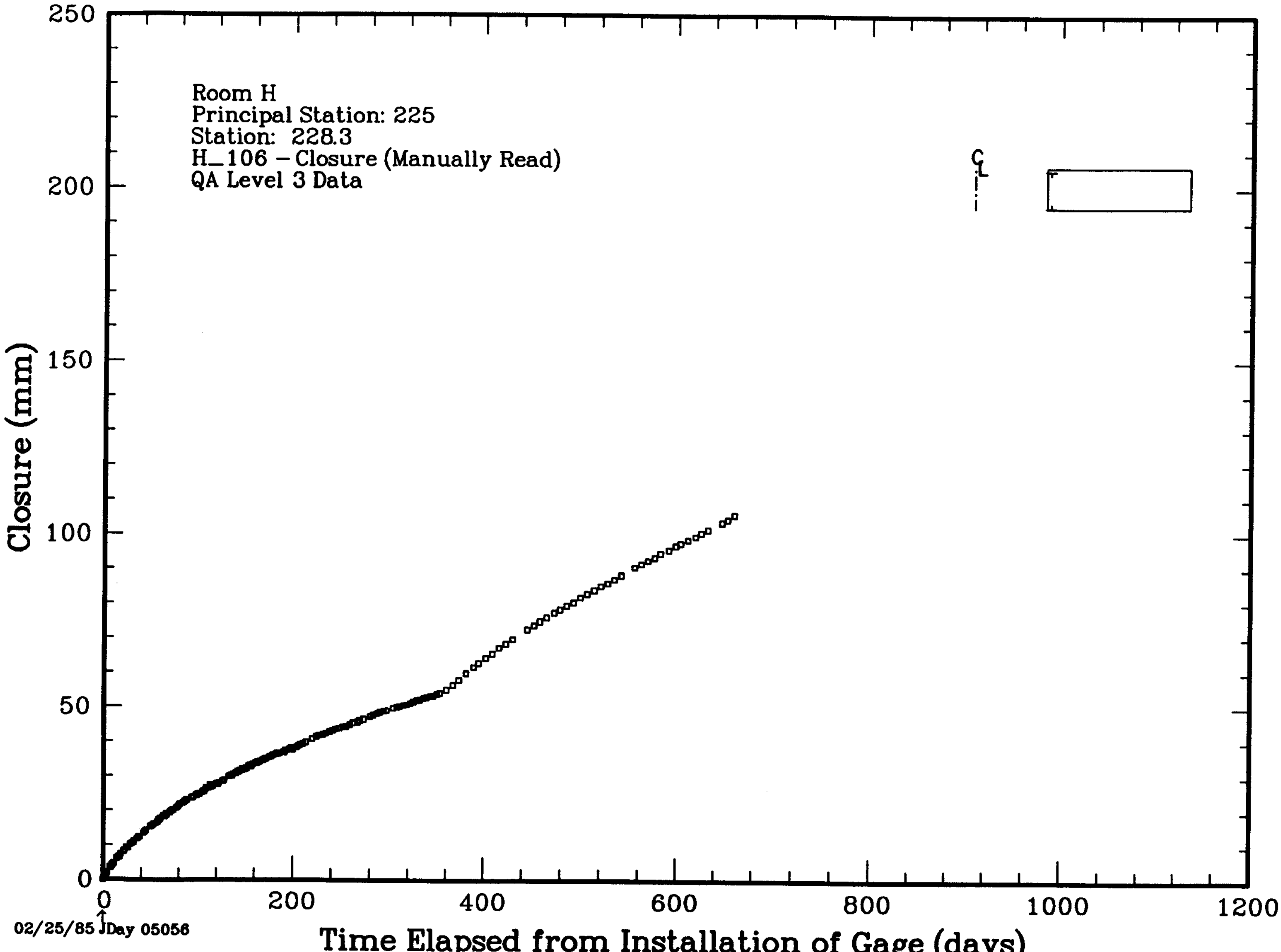

Figure 5.2.1f. Manual Closure Gage, H 106

Table 5.2.1g. Manual Closure Gage, H 107

Gage: H_107

****

***** H_107 PI Comments *****

11/24/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF ROOM H EXCAVATION. IT IS LOCATED NEXT TO THE RIB SURFACE AND MEASURES, TO A GOOD APPROXIMATION, RIB SHORTENING FROM THE TIME OF INSTALLATION. (DEM)

***** H_107 Location *****

Principal Station 225
Station 228.1

				Gage Coordinates											
Gage	Gage	Rec	Dir					Prin Stat		Room		Gage	Inst	PO	Comments
Number	Type			R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Manuf	Date	Item	
H_107-1	CONV	P MAN	V	16.15	16.14	228.07	228.06	-1.63	1.47	-1.71	1.38	SNL	02/25/85	T91025-000	

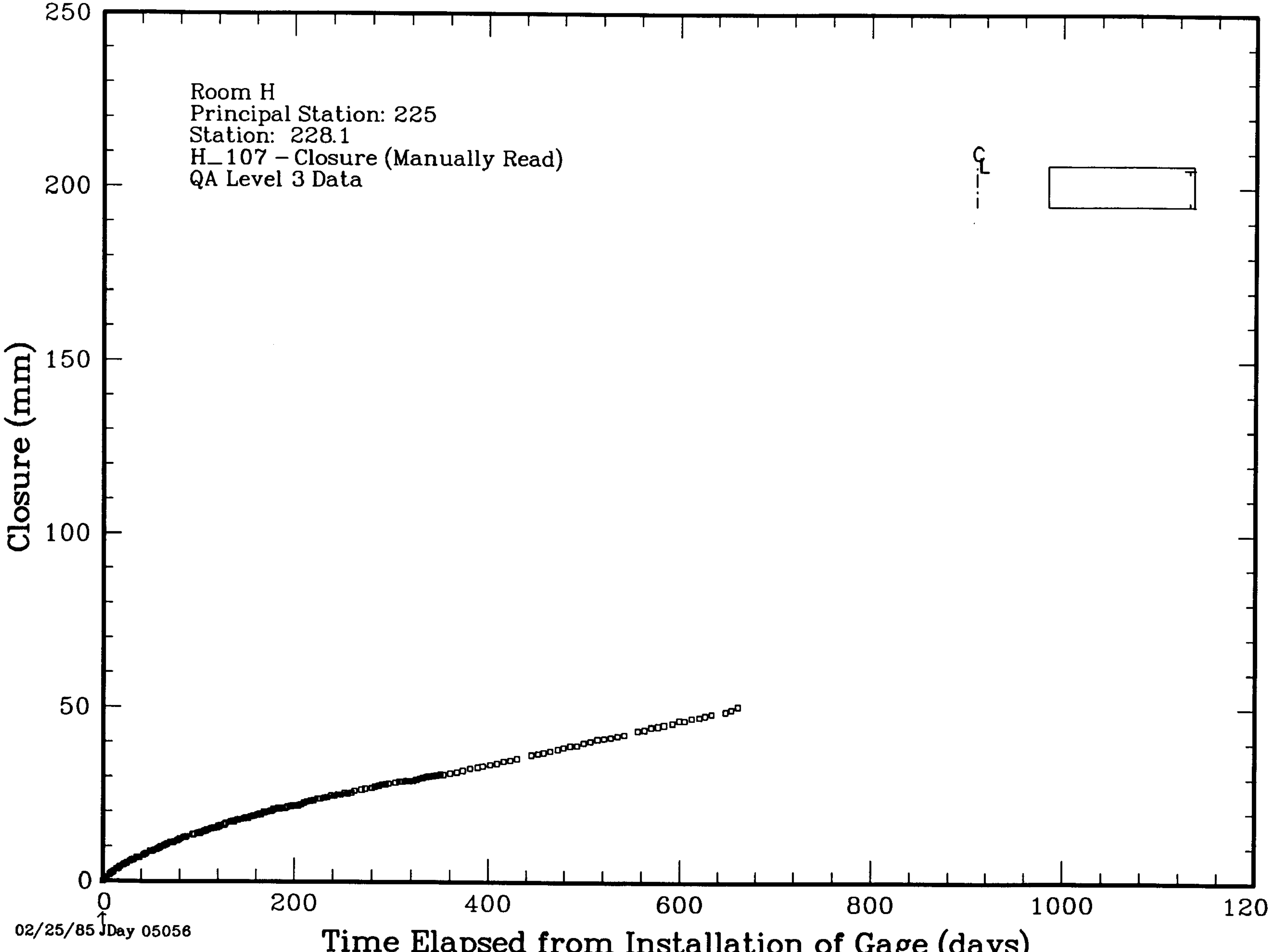

Figure 5.2.1g. Manual Closure Gage, H 107

Table 5.2.1h. Manual Closure Gage, H 108

Gage: H_108

****

***** H_108 PI Comments *****

11/24/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF MINING OF ROOM H. IT IS LOCATED ALMOST AT THE PILLAR SURFACE; AND THEREFORE, MEASURES TO A GOOD APPROXIMATION THE PILLAR SHORTENING FROM THE TIME OF INSTALLATION OF THE GAGE. (DEM)

***** H_108 Location *****

Principal Station 315
Station 319.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_108-1	CONV P	MAN	V	5.81	5.81	319.01	318.78	-1.12	1.52	-1.20	1.44	SNL	02/25/85	T91025-000	

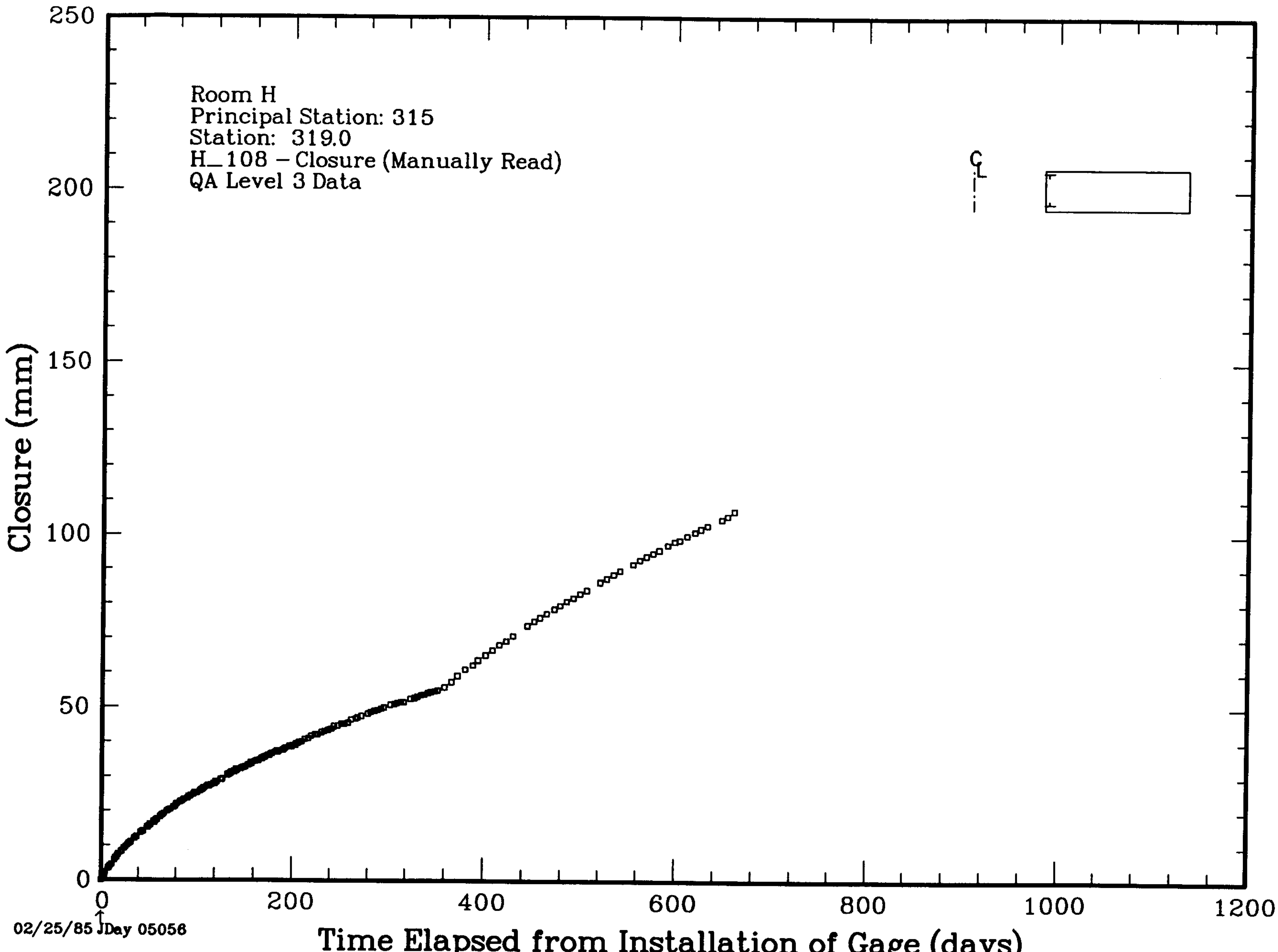

Figure 5.2.1h. Manual Closure Gage, H 108

Table 5.2.1i. Manual Closure Gage, H 109

Gage: H_109

****

***** H_109 PI Comments *****

11/24/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS PERMANENT GAGE WAS INSTALLED UPON COMPLETION OF MINING OF ROOM H. IT IS LOCATED ALMOST AT THE RIB SURFACE; AND THEREFORE, MEASURES TO A GOOD APPROXIMATION THE RIB SHORTENING FROM THE TIME OF INSTALLATION OF THE GAGE. (DEM)

***** H_109 Location *****

Principal Station 315
Station 317.9

				Gage Coordinates											
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_109-1	CONV P	MAN	V	16.16	16.15	317.87	317.82	-1.55	1.51	-1.64	1.42	SNL	02/25/85	T91025-000	

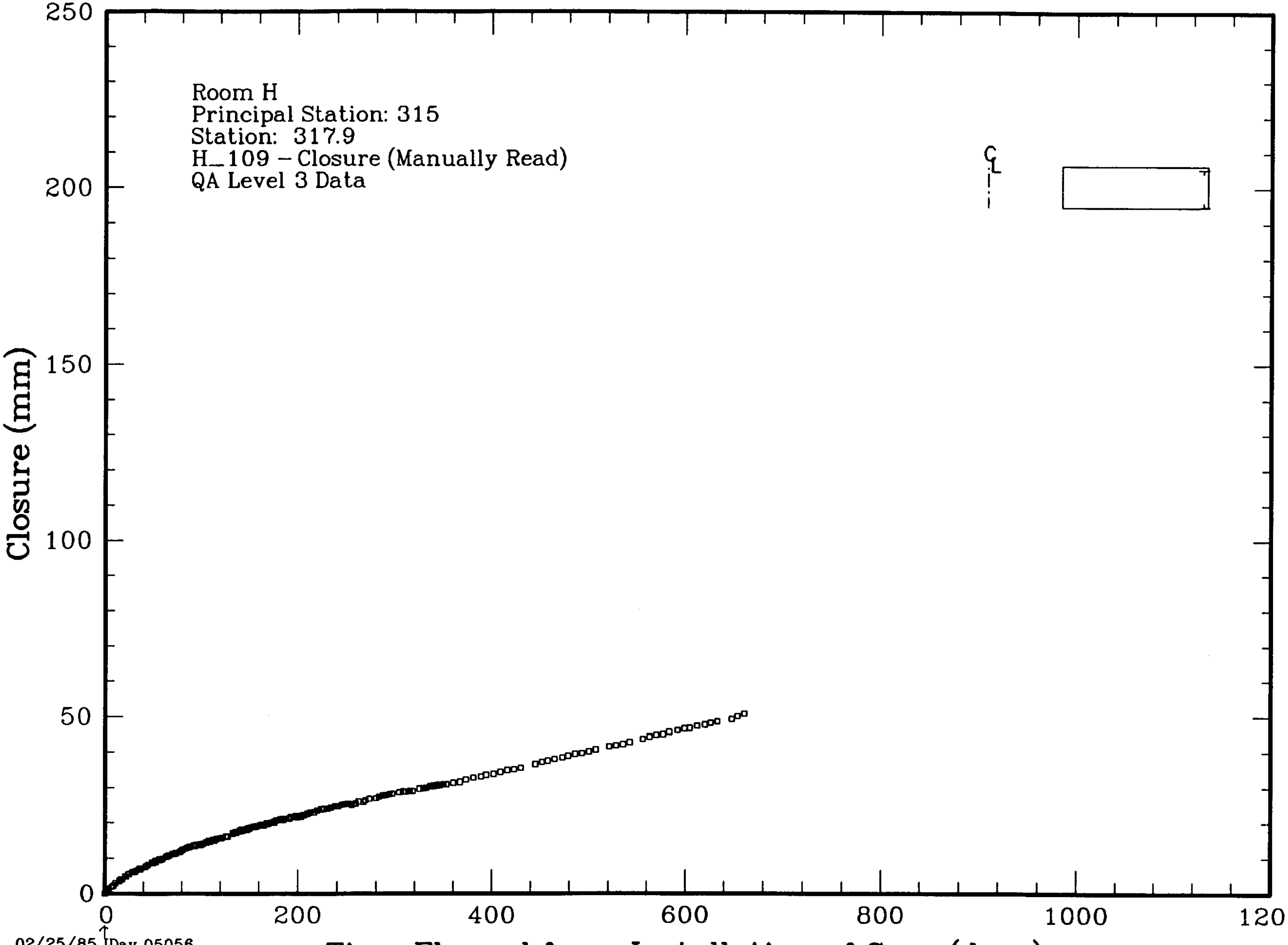

Figure 5.2.1i. Manual Closure Gage, H 109

Table 5.2.1j. Manual Closure Gage, H 110

Gage: H_110

****

***** H_110 PI Comments *****

11/24/87 RLJ [95%] THE DATA ARE OUTSTANDING. THIS GAGE WAS INSTALLED ADJACENT TO THE PILLAR SURFACE AFTER COMPLETION OF MINING OF THE ROOM. IT HAS MEASURED APPROXIMATELY THE PILLAR SHORTENING SINCE IT WAS INSTALLED. (DEM)

***** H_110 Location *****

Principal Station 045
Station 48.1

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_110-1	CONV P	MAN	V	5.81	5.79	48.10	48.04	-1.58	1.46	-1.51	1.52	SNL	02/25/85	T91025-000	

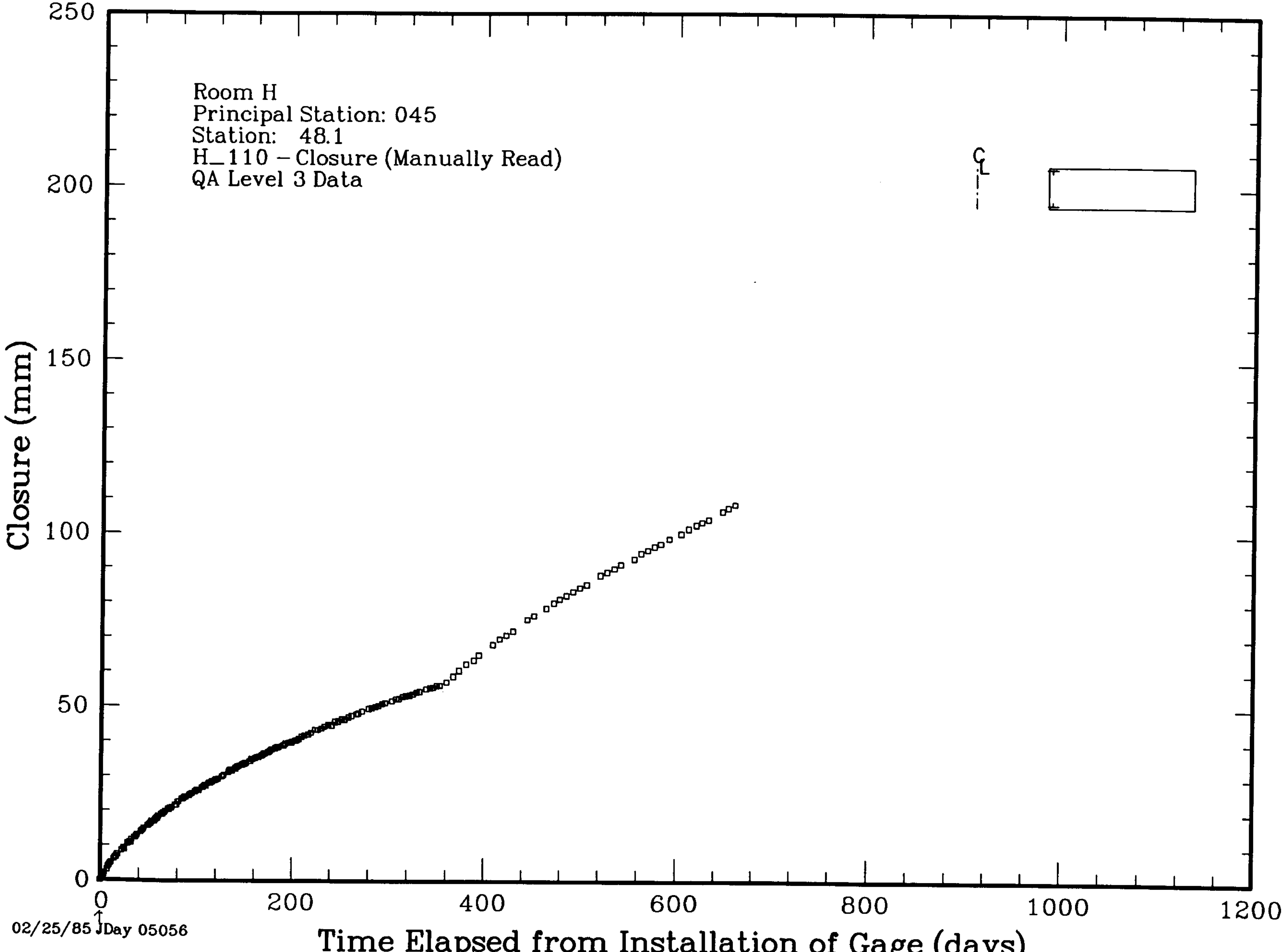

Figure 5.2.1j. Manual Closure Gage, H 110

Table 5.2.1k. Manual Closure Gage, H 111

Gage: H_111

****

***** H_111 PI Comments *****

11/24/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS GAGE WAS INSTALLED ADJACENT TO THE RIB SURFACE AFTER COMPLETION OF MINING OF THE ROOM. IT HAS MEASURED APROXIMATELY THE RIB SHORTENING SINCE IT WAS INSTALLED. (DEM)

***** H_111 Location *****

Principal Station 045
Station 48.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_111-1	CONV P	MAN	V	16.15	16.14	48.01	47.96	-1.58	1.46	-1.52	1.53	SNL	02/25/85	T91025-000	

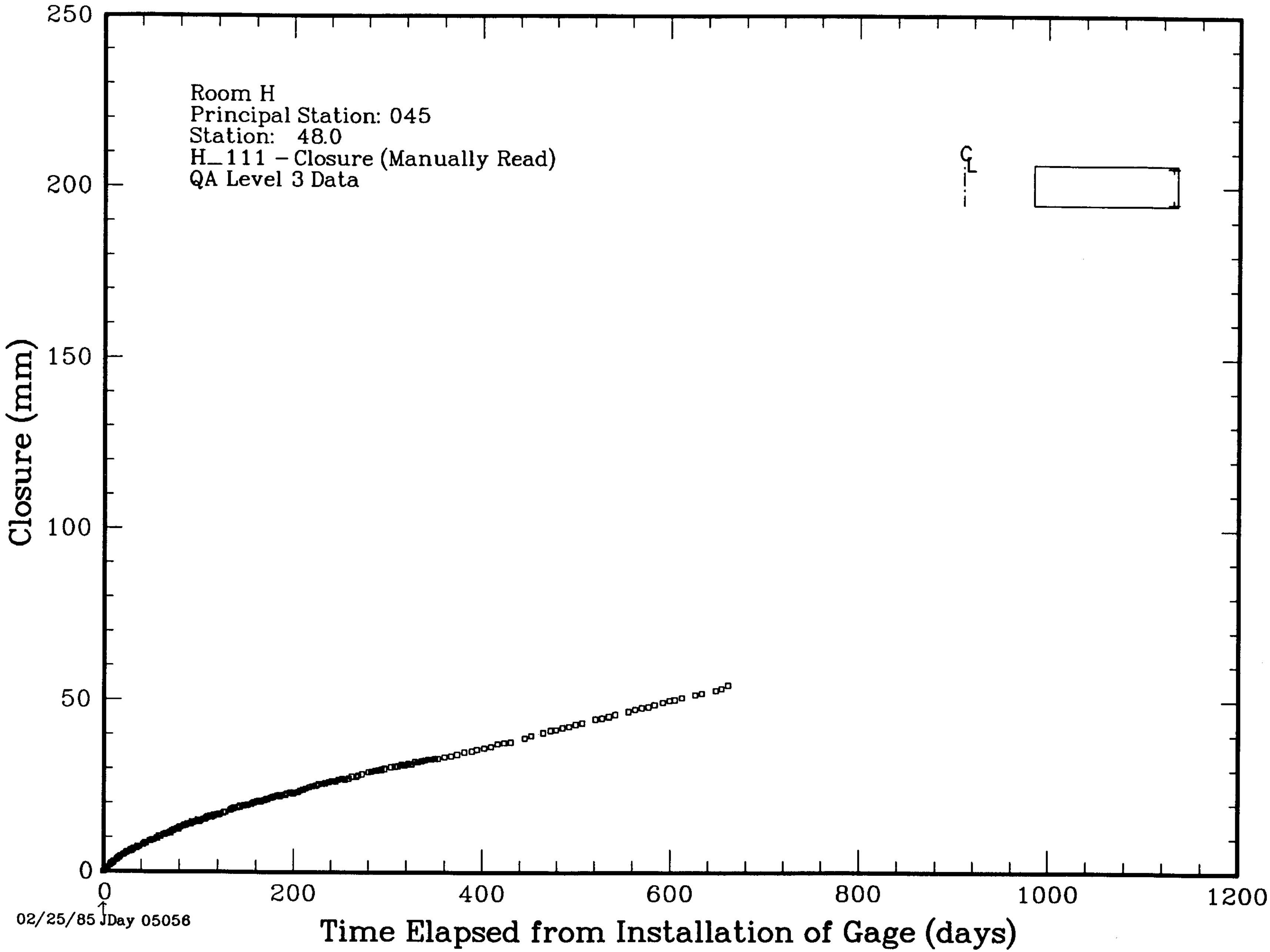

Figure 5.2.1k. Manual Closure Gage, H 111

Table 5.2.11. Manual Closure Gage, H 120

Gage: H_120

****

***** H_120 PI Comments *****

11/25/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS VERTICAL PERMANENT CLOSURE GAGE WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF EXCAVATION OF THE ROOM. IT HAS MEASURED THE MIDSPAN CLOSURE SINCE THAT TIME. (DEM)

***** H_120 Location *****

Principal Station 135
Station 132.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_120-1	CONV T	MAN	V	10.95	10.96	132.02	131.97	-1.52	1.65	-1.42	1.76	SNL	02/13/85	T91025-000	

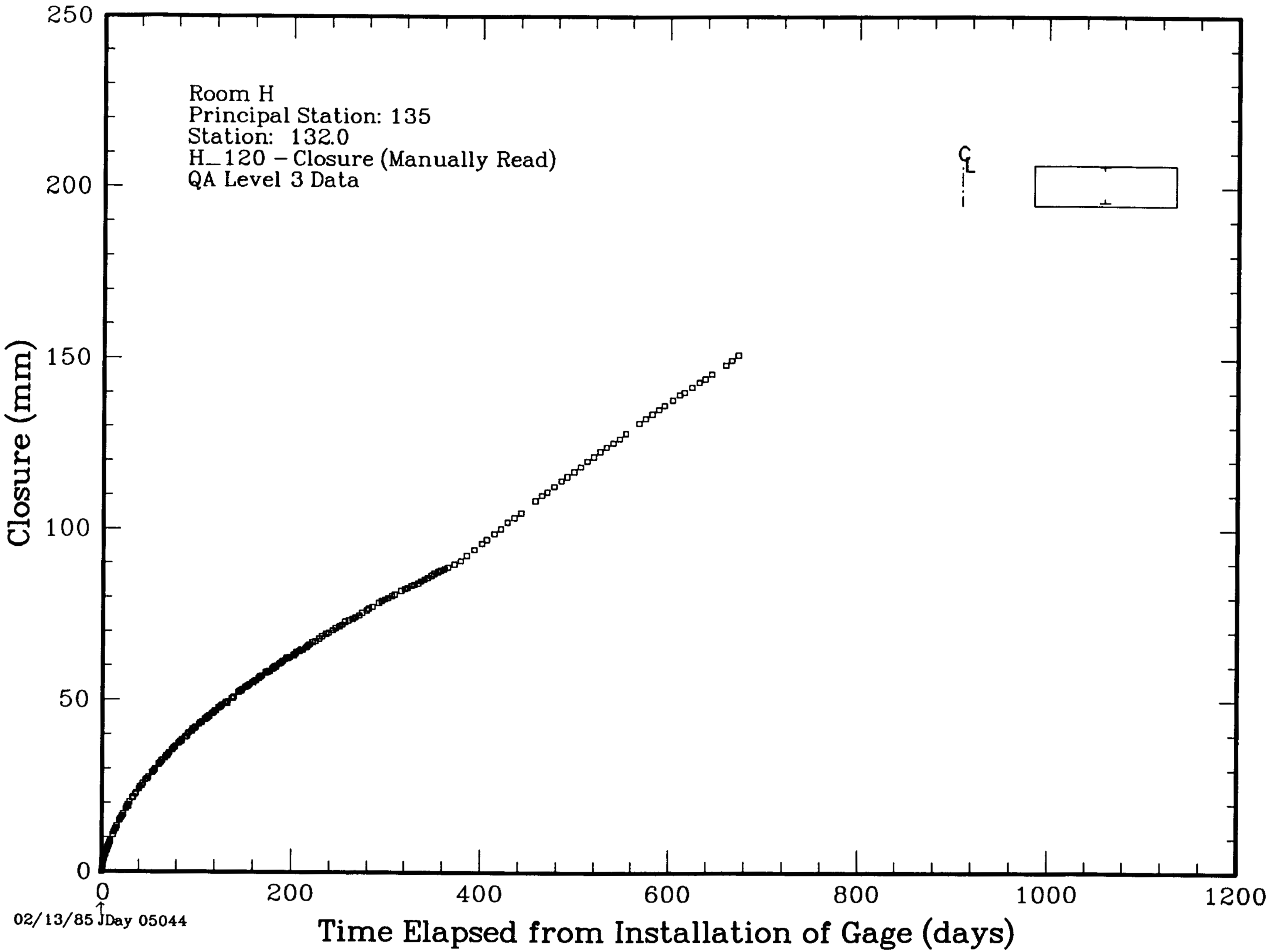

Figure 5.2.11. Manual Closure Gage, H 120

Table 5.2.1m. Manual Closure Gage, H 121

Gage: H_121

****

***** H_121 PI Comments *****

11/25/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS VERTICAL PERMANENT CLOSURE GAGE WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF EXCAVATION OF THE ROOM. IT HAS MEASURED THE MIDSPAN CLOSURE SINCE THAT TIME. (DEM)

***** H_121 Location *****

Principal Station 225
Station 221.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_121-1	CONV T	MAN	V	10.98	10.98	221.89	222.10	-1.56	1.63	-1.64	1.55	SNL	02/13/85	T91025-000	

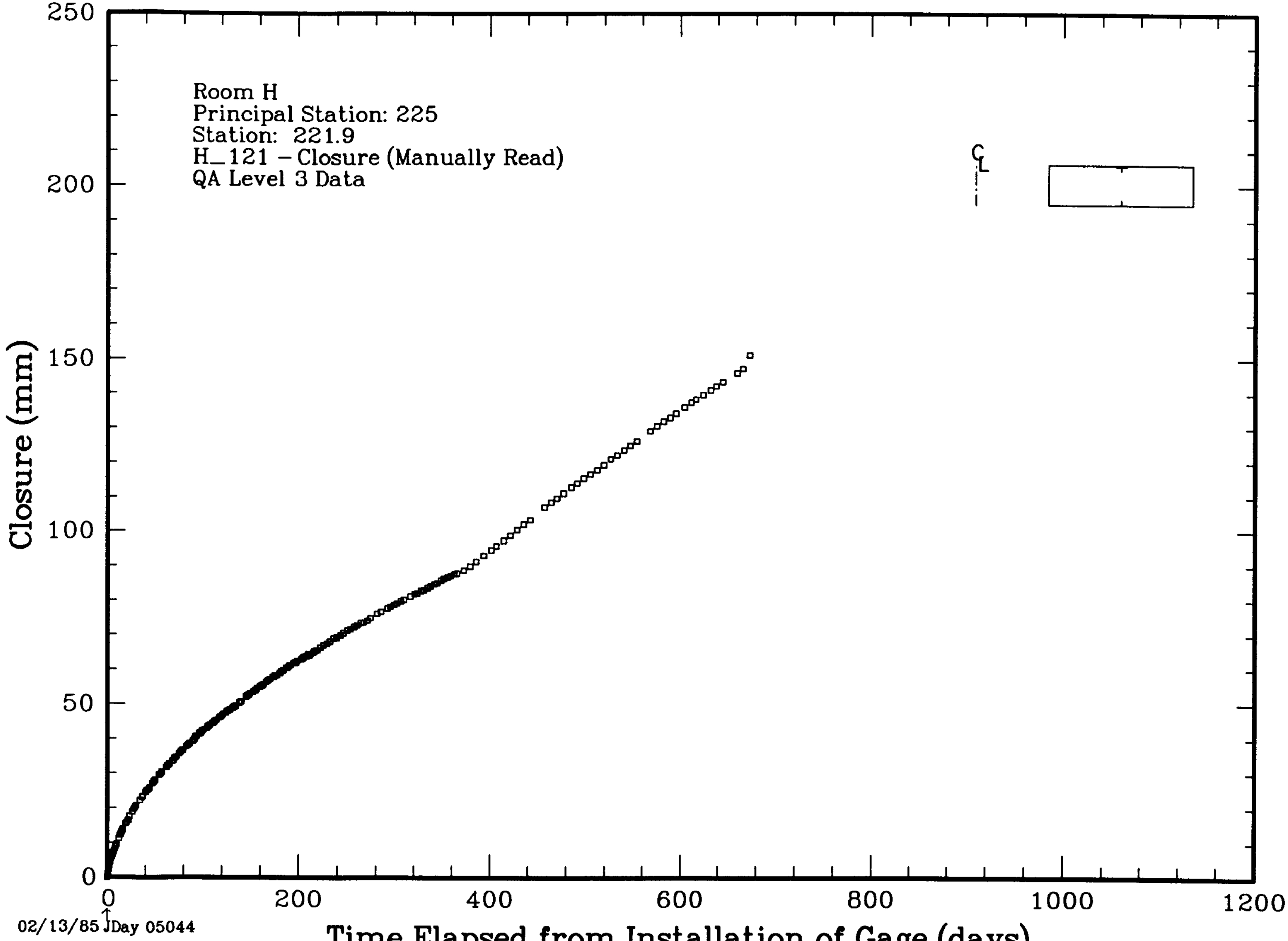

Figure 5.2.1m. Manual Closure Gage, H 121

Table 5.2.1n. Manual Closure Gage, H 122

Gage: H_122

****

***** H_122 PI Comments *****

11/25/87 RLJ [97%] THE DATA ARE OUTSTANDING. THIS VERTICAL PERMANENT CLOSURE GAGE WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF EXCAVATION OF THE ROOM. IT HAS MEASURED THE MIDSPAN CLOSURE SINCE THAT TIME. (DEM)

***** H_122 Location *****

Principal Station 315
Station 312.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates Prin Stat R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_122-1	CONV	T MAN	V	11.00	11.06	311.99	311.97	-1.58	1.51	-1.66	1.42	SNL	02/13/85	T91025-000	

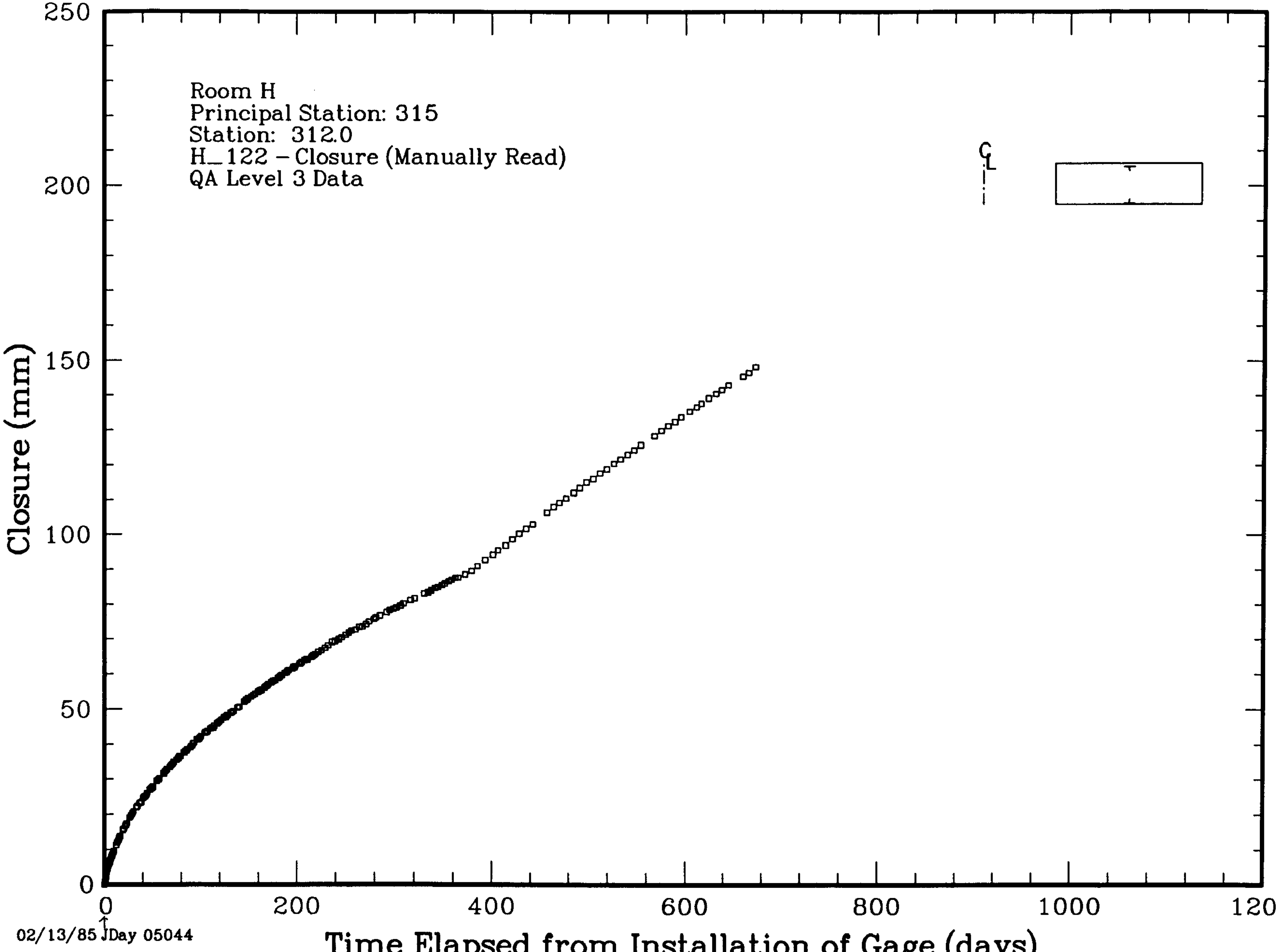

Figure 5.2.1n. Manual Closure Gage, H 122

Table 5.2.1o. Manual Closure Gage, H 123

Gage: H_123

****

***** H_123 PI Comments *****

11/25/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS VERTICAL PERMANENT CLOSURE GAGE WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF EXCAVATION OF THE ROOM. IT HAS MEASURED THE MIDSPAN CLOSURE SINCE THAT TIME. (DEM)

***** H_123 Location *****

Principal Station 045
Station 41.8

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_123-1	CONV T	MAN	V	10.98	10.97	41.84	42.21	-1.58	1.58	-1.51	1.64	SNL	02/13/85	T91025-000	

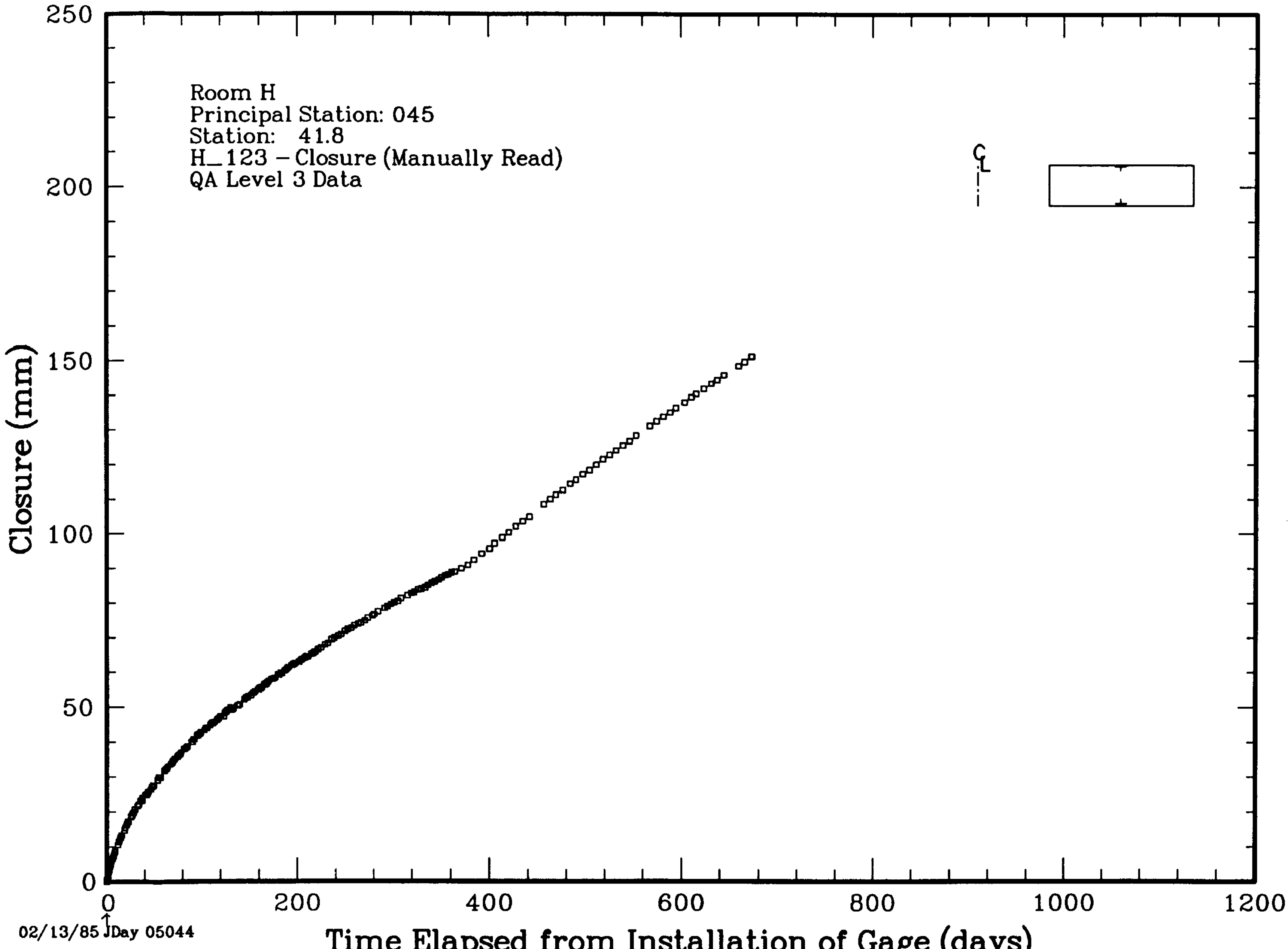

Figure 5.2.1o. Manual Closure Gage, H 123

Table 5.2.1p. Manual Closure Gage, H 124

Gage: H_124

****

***** H_124 PI Comments *****

11/25/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS HORIZONTAL PERMANENT CLOSURE GAGE HAS BEEN MEASURING CLOSURE SINCE IT WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF MINING OF THE ROOM. (DEM)

***** H_124 Location *****

Principal Station 135
Station 131.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_124-1	CONV T	MAN	H	5.47	16.44	131.94	131.89	0.07	0.07	0.17	0.18	SNL	02/13/85	T91025-000	

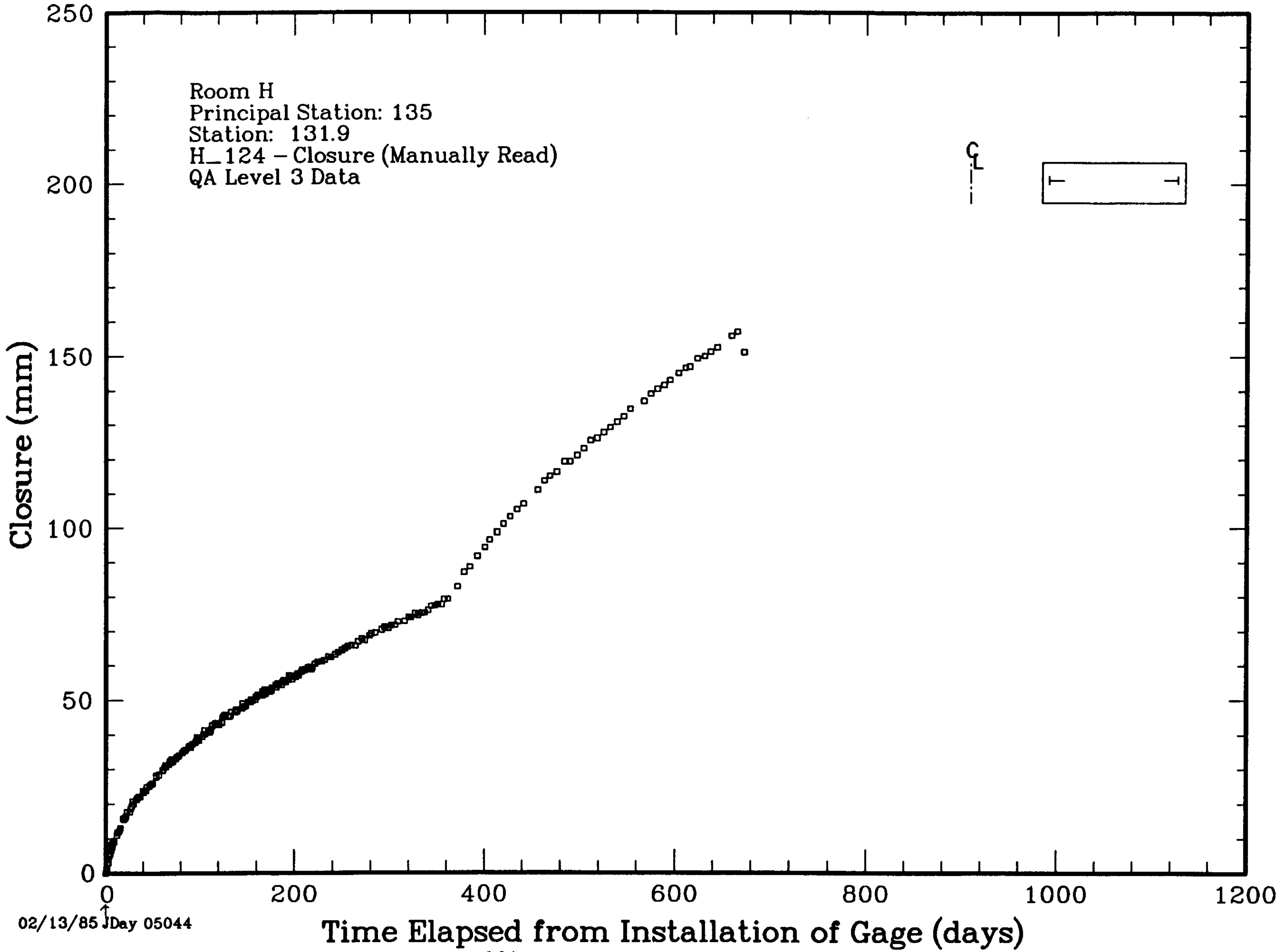

Figure 5.2.1p. Manual Closure Gage, H 124

Table 5.2.1q. Manual Closure Gage, H 125

Gage: H_125

****

***** H_125 PI Comments *****

11/25/87 RLJ [98%] THE DATA ARE OUTSTANDING. THIS HORIZONTAL PERMANENT CLOSURE GAGE HAS BEEN MEASURING CLOSURE SINCE IT WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF MINING OF THE ROOM. (DEM)

***** H_125 Location *****

Principal Station 225
Station 221.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_125-1	CONV T	MAN	H	16.46	5.45	221.94	222.13	-0.03	-0.01	-0.12	-0.09	SNL	02/13/85	T91025-000	

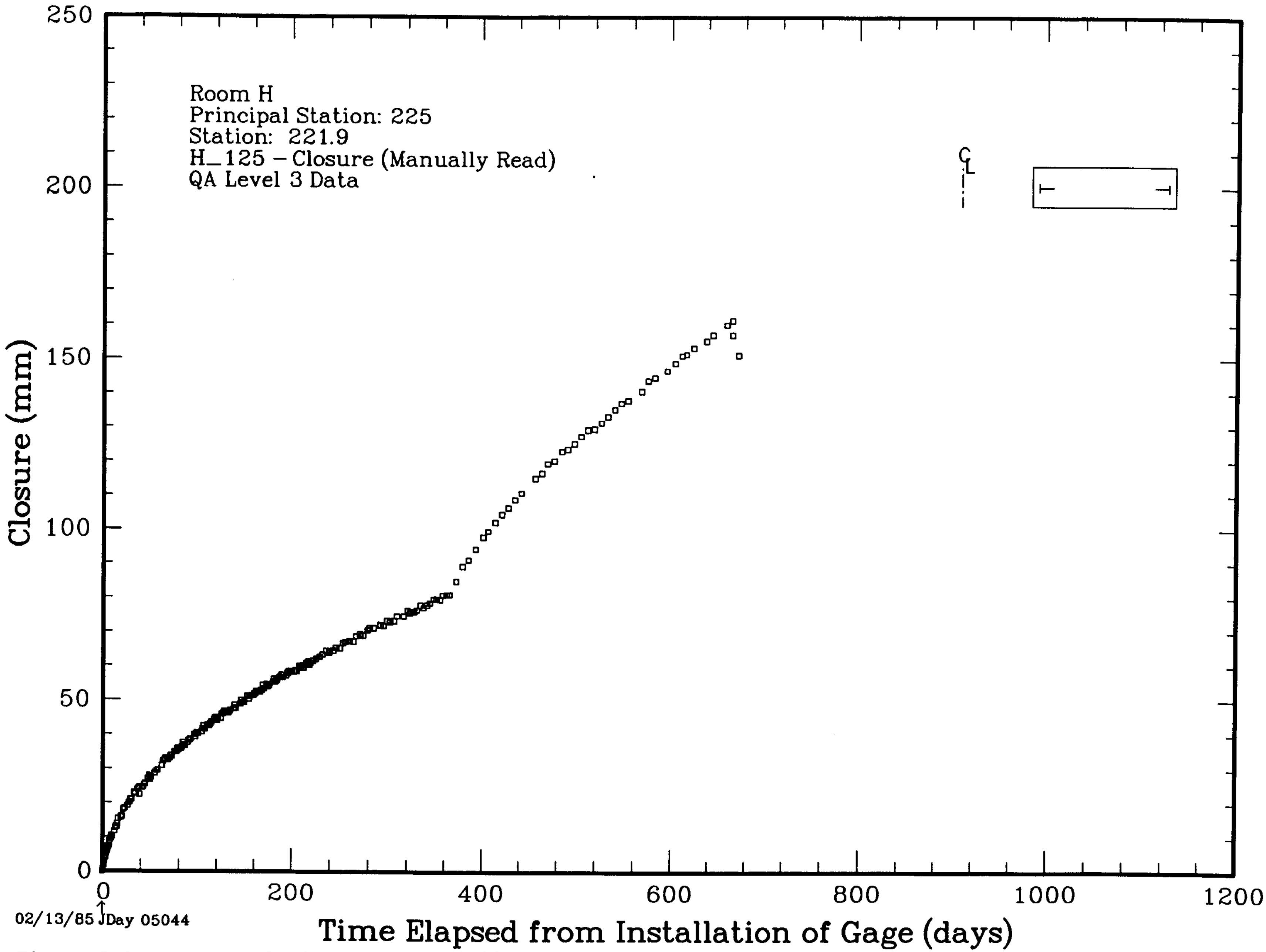

Figure 5.2.1q. Manual Closure Gage, H 125

Table 5.2.1r. Manual Closure Gage, H 126

Gage: H_126

****

***** H_126 PI Comments *****

11/25/87 RLJ [100%] THE DATA ARE OUTSTANDING. THIS HORIZONTAL PERMANENT CLOSURE GAGE HAS BEEN MEASURING CLOSURE SINCE IT WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF MINING OF THE ROOM. (DEM)

***** H_126 Location *****

Principal Station 315
Station 312.4

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_126-1	CONV T	MAN	H	16.47	5.51	312.36	310.97	0.01	0.01	-0.07	-0.07	SNL	02/13/85	T91025-000	

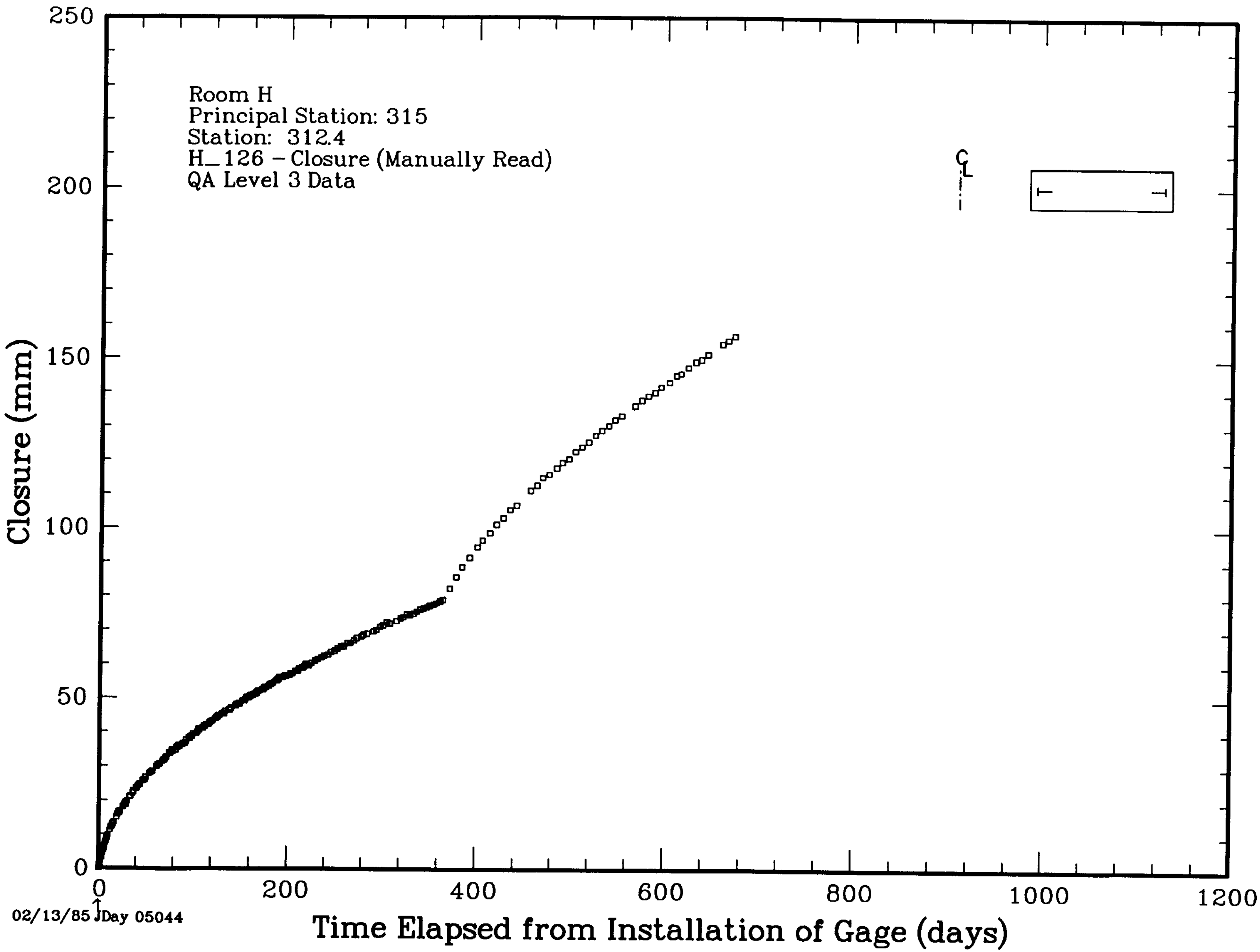

Figure 5.2.1r. Manual Closure Gage, H 126

Table 5.2.1s. Manual Closure Gage, H 127

Gage: H_127

****

***** H_127 PI Comments *****

11/25/87 RLJ [99%] THE DATA ARE OUTSTANDING. THIS HORIZONTAL PERMANENT CLOSURE GAGE HAS BEEN MEASURING CLOSURE SINCE IT WAS INSTALLED IMMEDIATELY AFTER COMPLETION OF MINING OF THE ROOM. (DEM)

***** H_127 Location *****

Principal Station 045
Station 42.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_127-1	CONV T	MAN	H	5.47	16.48	42.05	41.77	0.06	0.06	0.12	0.12	SNL	02/13/85	T91025-000	

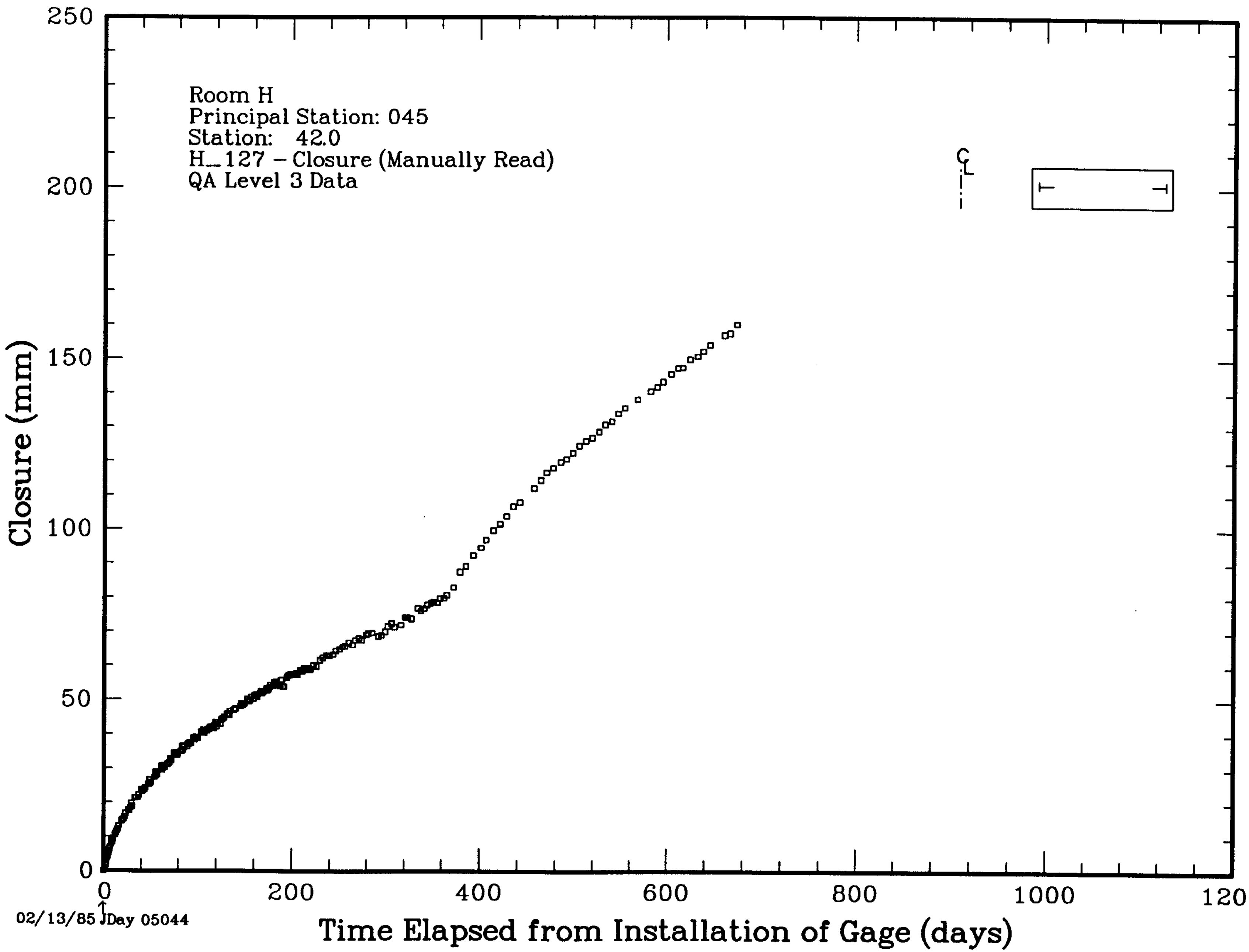

Figure 5.2.1s. Manual Closure Gage, H 127

Table 5.2.2a. Remote Closure Gage, H 201

Gage: H_201

****

***** H_201 PI Comments *****

08/06/87 DLH [RANK = 9] THE DATA ARE EXCEPTIONAL, WITH ONLY A FEW REDUCTION SHIFTS REQUIRED FROM DISCONNECTIONS. [COMPRESSION = 3.75:1] (DEM)

***** H_201 Location *****

Principal Station 135
Station 134.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates Prin Stat R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_201-1	CONV	P REM	V	10.98	10.96	134.93	135.00	-1.46	1.46	-1.35	1.56	R.I.	03/15/85	T91997-000	

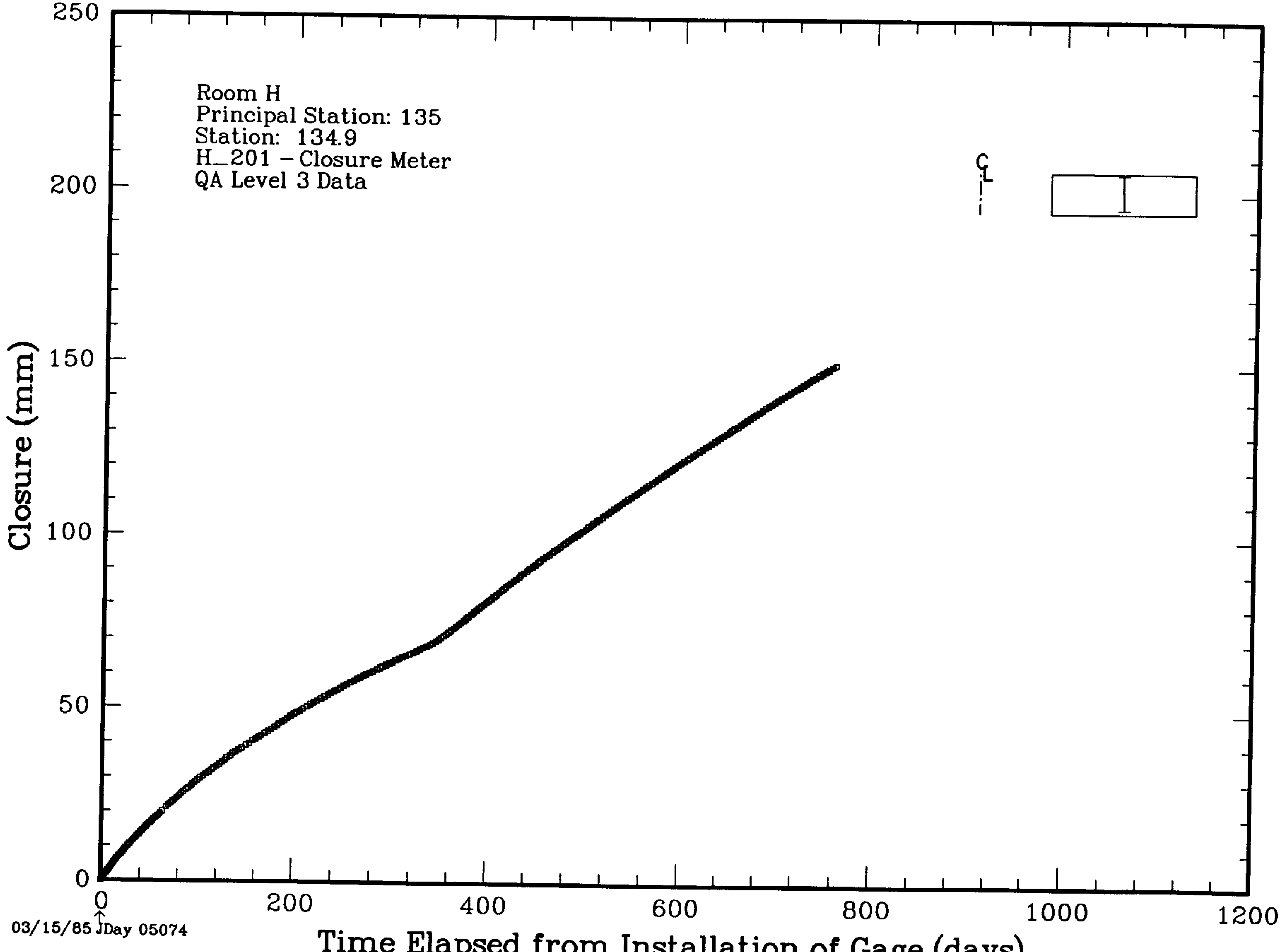

Figure 5.2.2a. Remote Closure Gage, H 201

Table 5.2.2b. Remote Closure Gage, H 202

Gage: H_202

****

***** H_202 PI Comments *****

08/06/87 DLH [RANK = 9] THE DATA ARE EXCEPTIONAL, WITH ONLY A FEW REDUCTION SHIFTS REQUIRED FROM DISCONNECTIONS. [COMPRESSION =3.89:1] (DEM)

***** H_202 Location *****

Principal Station 225
Station 225.1

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_202-1	CONV	P REM	V	10.97	10.96	225.05	224.96	-1.50	1.50	-1.58	1.41	R.I.	03/22/85	T91997-000	

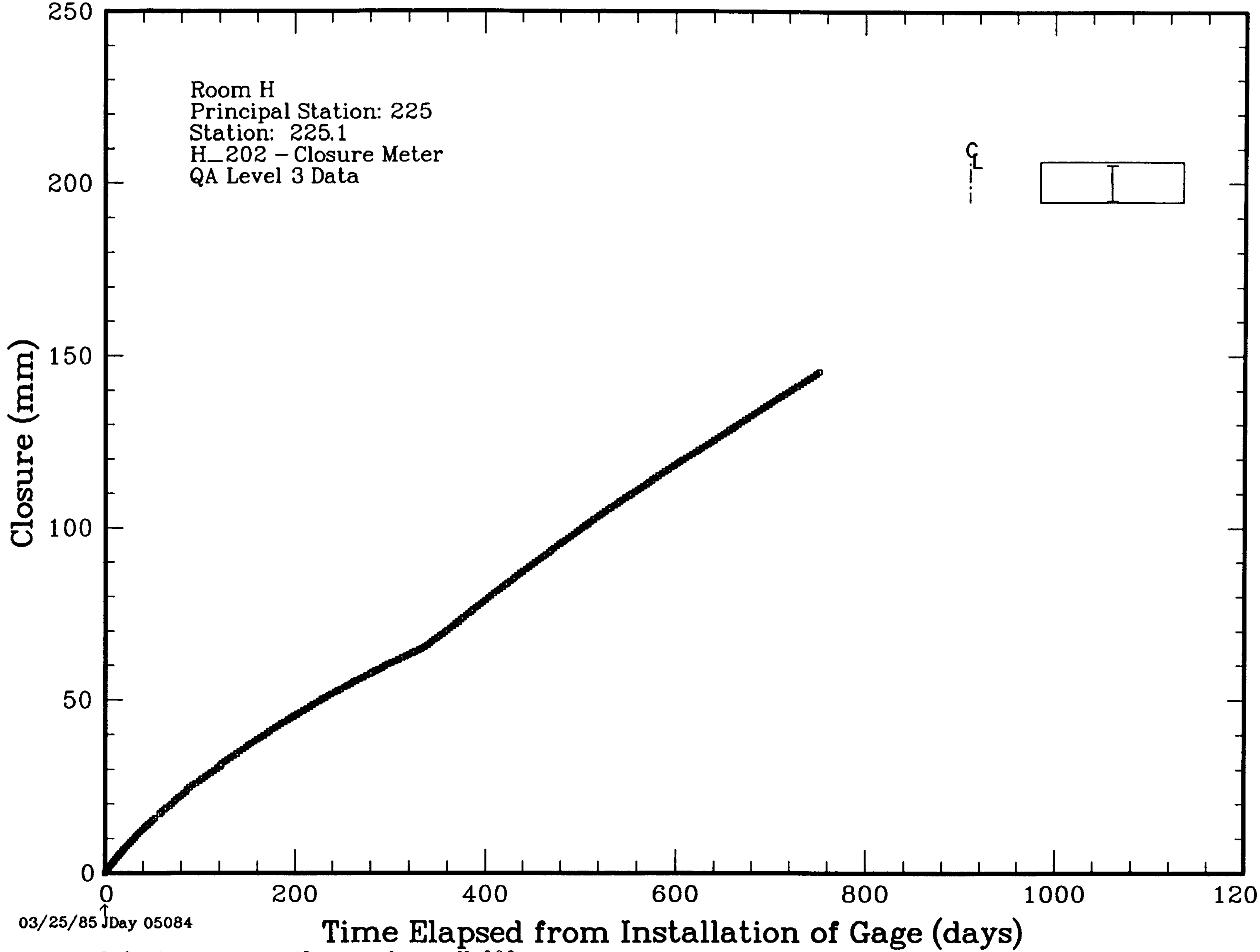

Figure 5.2.2b. Remote Closure Gage, H 202

Table 5.2.2c. Remote Closure Gage, H 203

Gage: H_203

****

***** H_203 PI Comments *****

08/06/87 DLH [RANK = 9] THE DATA ARE EXCEPTIONAL, WITH ONLY A FEW REDUCTION SHIFTS REQUIRED FROM DISCONNECTIONS. [COMPRESSION = 3.82:1] (DEM)

***** H_203 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_203-1	CONV	P REM	V	10.96	10.97	315.03	315.03	-1.42	1.42	-1.50	1.34	R.I.	03/15/85	T91997-000	

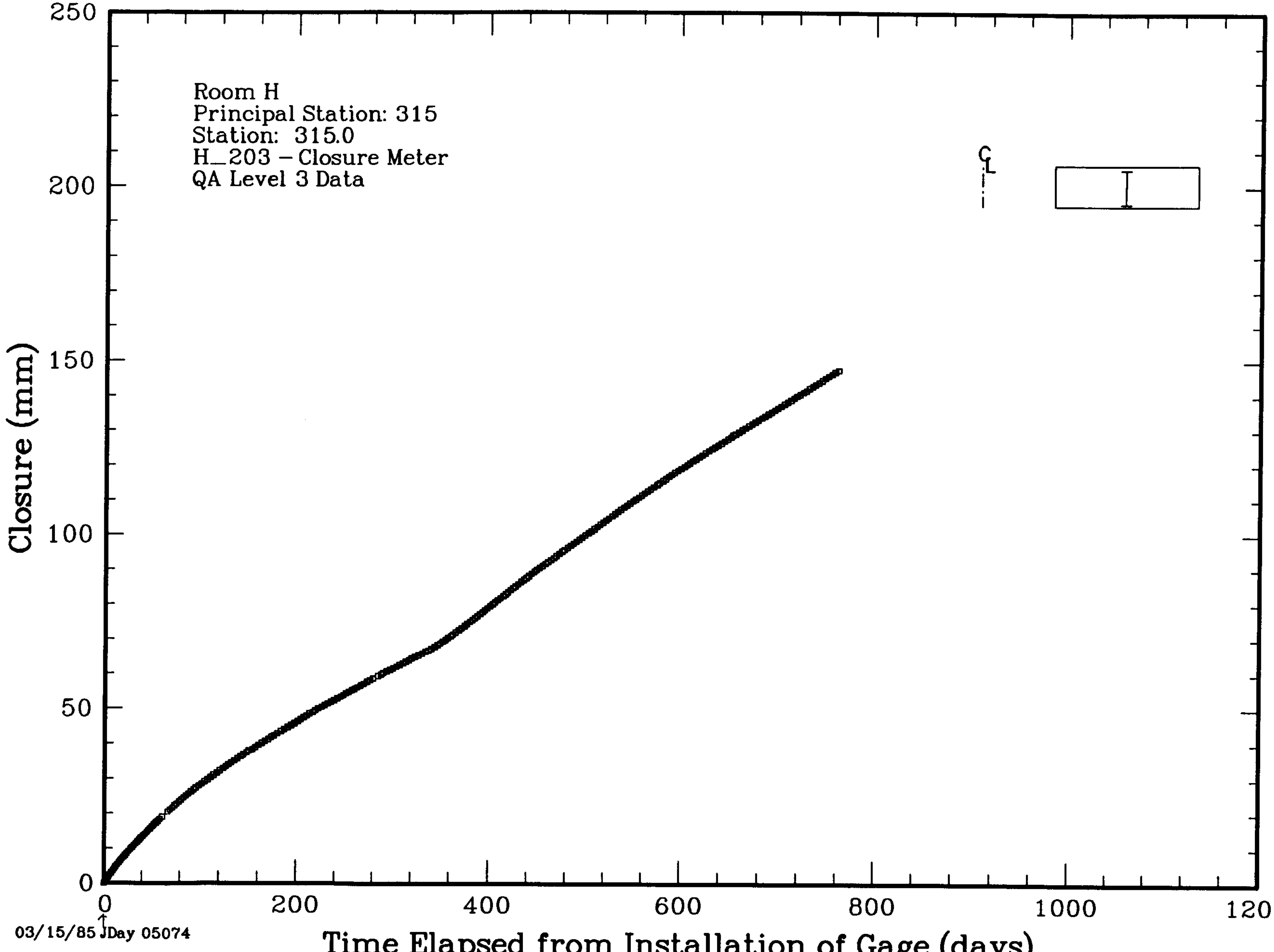

Figure 5.2.2c. Remote Closure Gage, H 203

Table 5.2.2d. Remote Closure Gage, H 204

Gage: H_204

****

***** H_204 PI Comments *****

08/06/87 DLH [RANK = 9] THE DATA ARE EXCEPTIONAL, WITH ONLY A FEW REDUCTION SHIFTS REQUIRED FROM DISCONNECTIONS. [COMPRESSION = 3.71:1] (DEM)

***** H_204 Location *****

Principal Station 045
Station 44.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_204-1	CONV	P REM	V	10.99	10.98	44.93	44.96	-1.47	1.47	-1.41	1.54	R.I.	03/21/85	T91997-000	

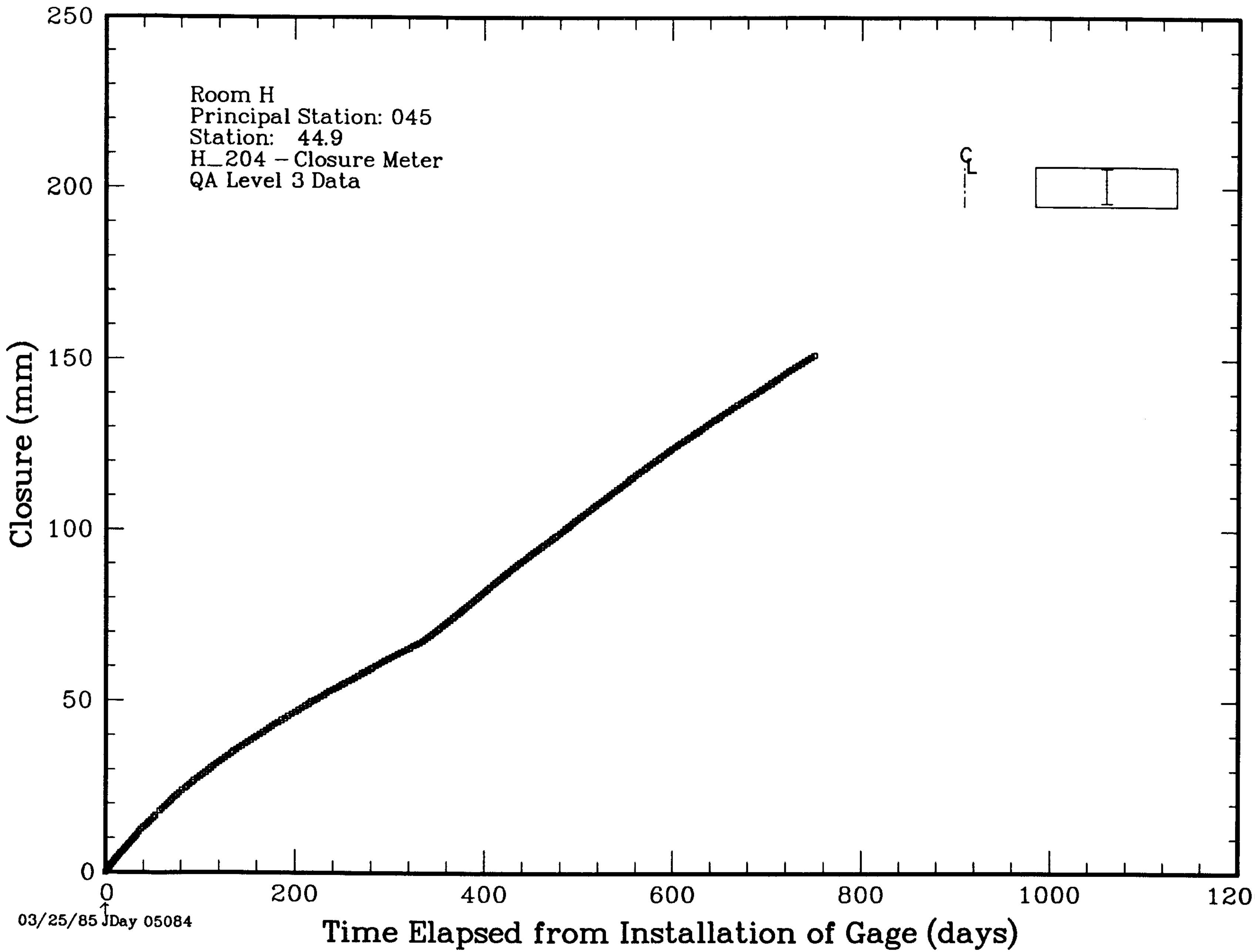

Figure 5.2.2d. Remote Closure Gage, H 204

Table 5.2.2e. Remote Closure Gage, H 205

Gage: H_205

****

***** H_205 PI Comments *****

08/13/87 DLH [RANK = 8] THE DATA ARE EXCELLENT; HOWEVER, THE LOCATION OF THE GAGE RESULTED IN MANY DISCONNECTIONS, WITH THE ASSOCIATED SMALL SHIFTS AND HYSTERESIS EFFECTS WHICH HAD TO BE CORRECTED. [COMPRESSION = 4.74:1] (DEM)

***** H_205 Location *****

Principal Station 135
Station 135.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_205-1	CONV	P REM	H	16.34	5.60	134.97	134.79	0.07	0.06	0.17	0.17	R.I.	03/15/85	T91997-000	

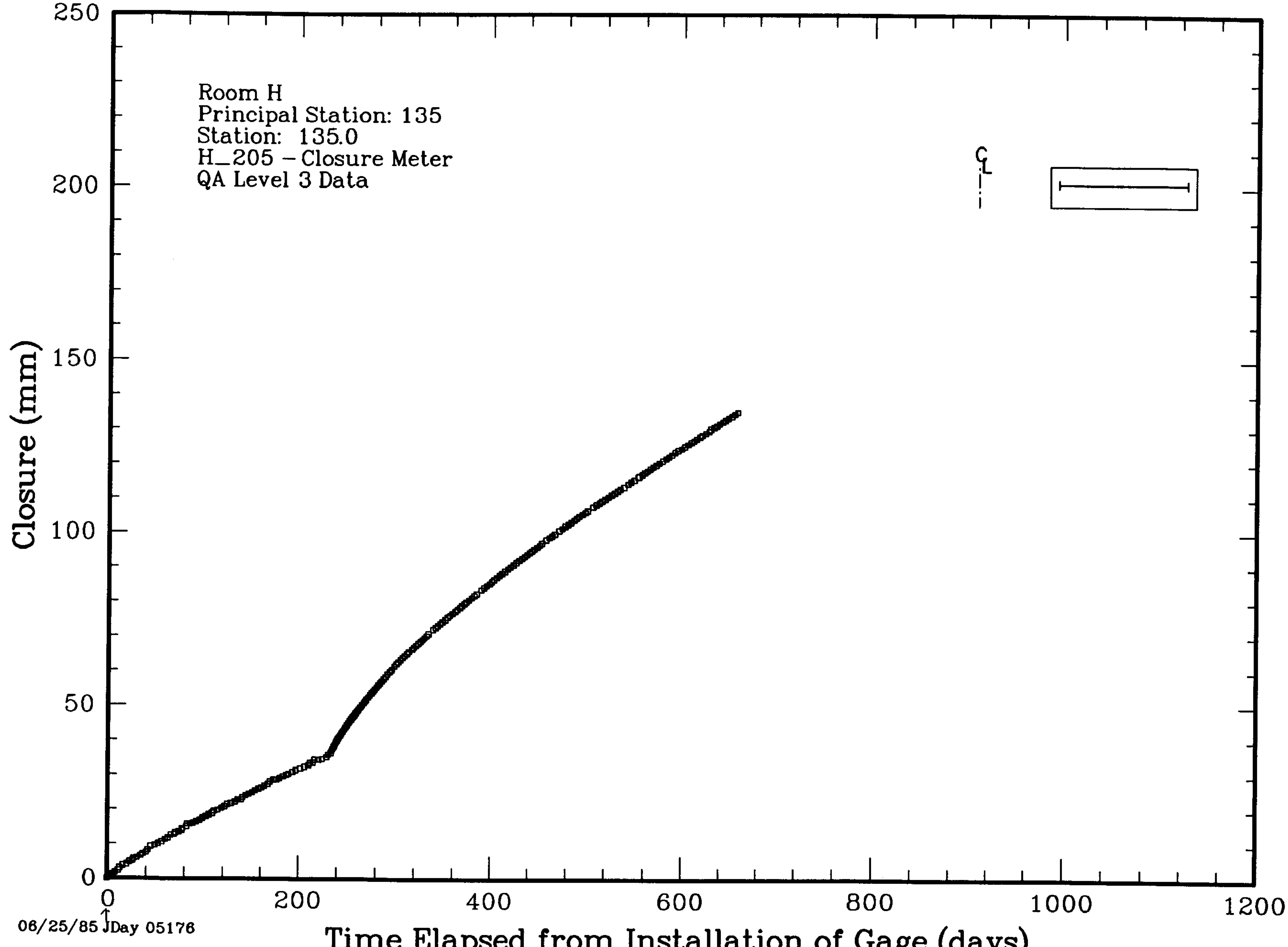

Figure 5.2.2e. Remote Closure Gage, H 205

Table 5.2.2f. Remote Closure Gage, H 206

Gage: H_206

****

***** H_206 PI Comments *****

08/13/87 DLH [RANK =8] THE DATA ARE EXCELLENT; HOWEVER, THE LOCATION OF THE GAGE RESULTED IN MANY DISCONNECTIONS, WITH THE ASSOCIATED SMALL SHIFTS AND HYSTERESIS EFFECTS WHICH HAD TO BE CORRECTED. [COMPRESSION = 5.75:1] (DEM)

***** H_206 Location *****

Principal Station 225
Station 225.0

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_206-1	CONV P	REM	H	16.37	5.57	224.98	224.97	-0.07	-0.05	-0.16	-0.13	R.I.	03/22/85	T91997-000	

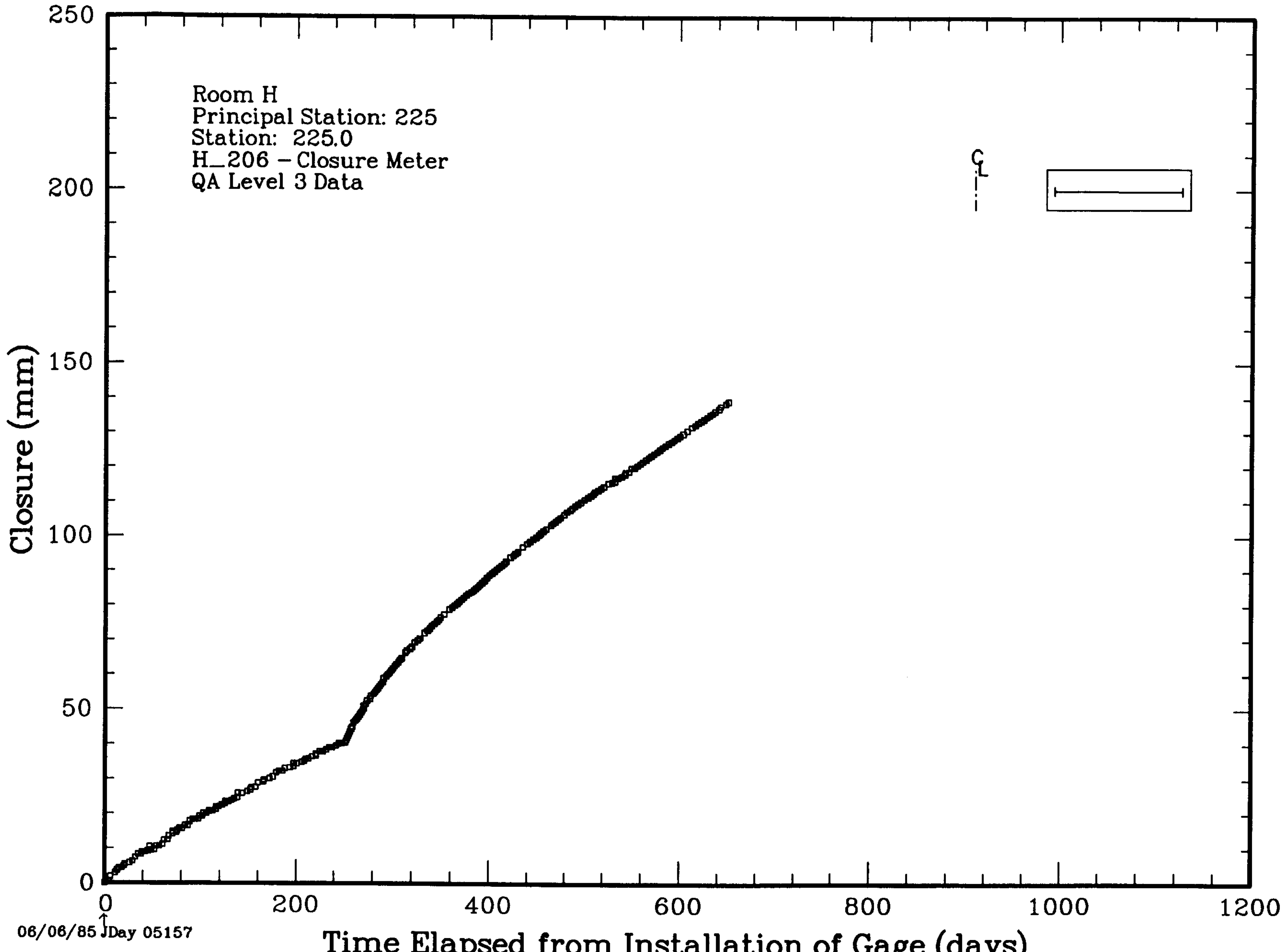

Figure 5.2.2f. Remote Closure Gage, H 206

Table 5.2.2g. Remote Closure Gage, H 207

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+----------------------+
|    Gage:  H_207      |
+----------------------+
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***** H_207 PI Comments *****

09/20/87 DLH [RANK = 8] THE DATA ARE EXCELLENT; HOWEVER, THE LOCATION OF THE GAGE RESULTED IN MANY DISCONNECTIONS, WITH THE ASSOCIATED SMALL SHIFTS AND HYSTERESIS EFFECTS THAT REQUIRED CORRECTION. [COMPRESSION RATIO = 3.61:1] (DEM)

***** H_207 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_207-1	CONV P	REM	H	16.36	5.59	314.99	315.05	0.00	0.00	-0.08	-0.08	R.I.	03/15/85	T91997-000	

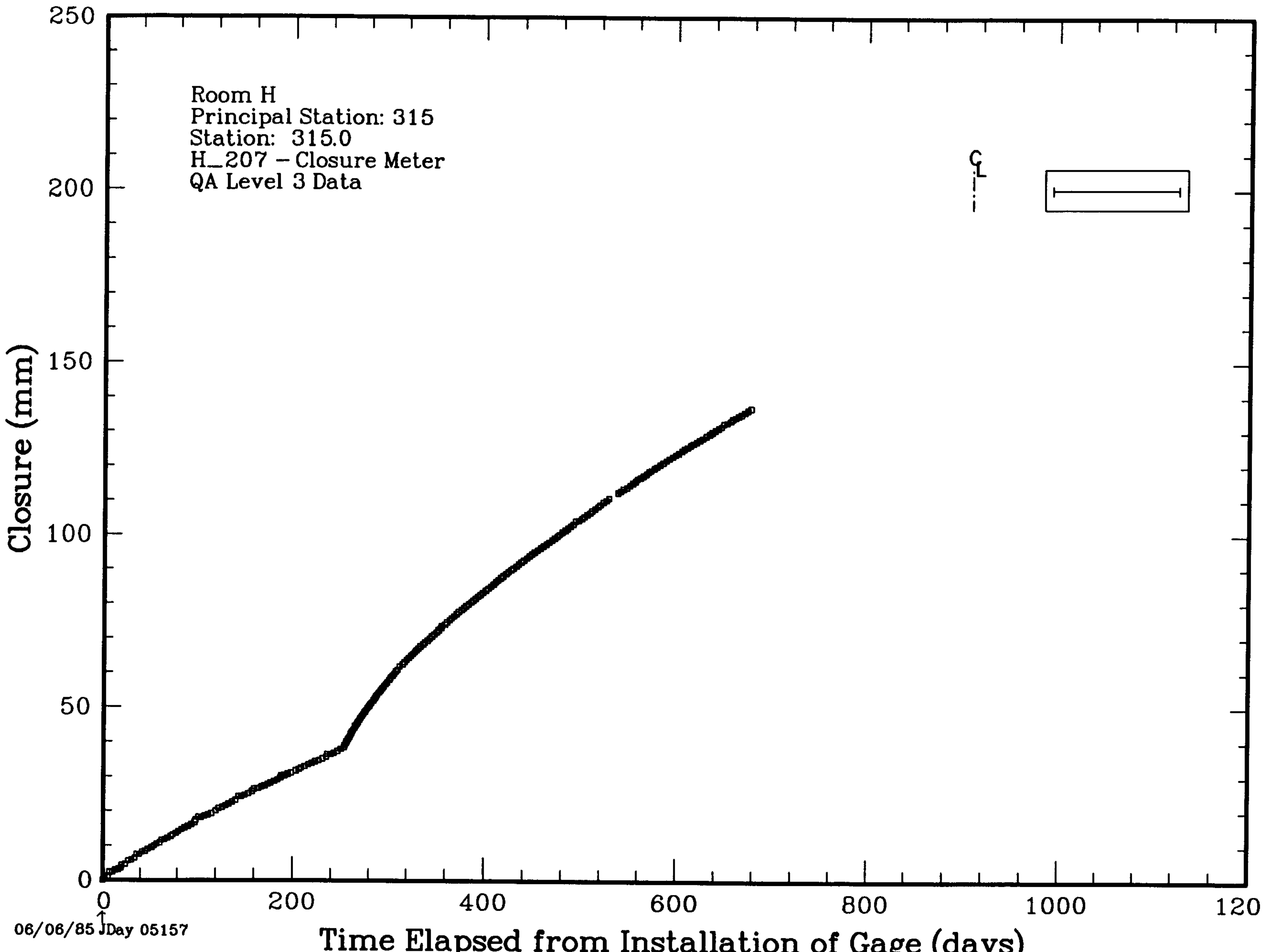

Figure 5.2.2g. Remote Closure Gage, H 207

Table 5.2.2h. Remote Closure Gage, H 208

Gage: H_208

****

***** H_208 PI Comments *****

09/20/87 DLH [RANK = 8] THE DATA ARE EXCELLENT; HOWEVER, THE LOCATION OF THE GAGE RESULTED IN MANY DISCONNECTIONS, WITH ASSOCIATED SMALL SHIFTS AND HYSTERESIS EFFECTS THAT REQUIRED CORRECTION. [COMPRESSION RATIO = 3.93:1] (DEM)

***** H_208 Location *****

Principal Station 045
Station 45.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_208-1	CONV P	REM	H	5.56	16.40	44.95	45.03	-0.07	-0.06	-0.01	0.00	R.I.	03/22/85	T91997-000	

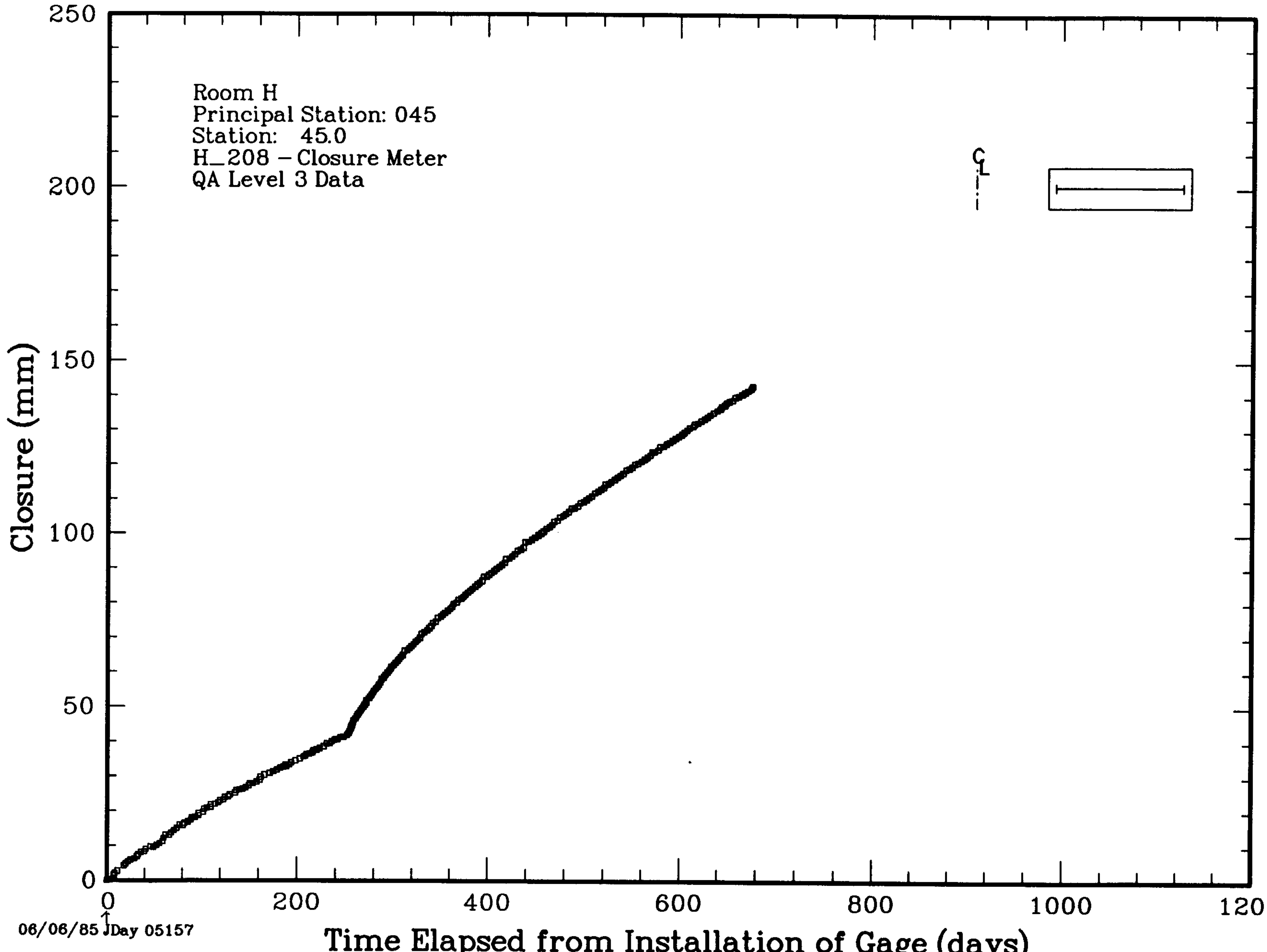

Figure 5.2.2h. Remote Closure Gage, H 208

5.3 Extensometer Measurements

A guide to all temporary and permanent extensometer units (gages) installed in Room H is given in Table 5.3.1. The table illustrates schematically the relative gage positions at the principal stations of the room. Noted angular positions of the diagonal gages are nominal rather than exact. In general, the gage numbers of logical collections of gages are in sequence. Thus, H 301 through H 308 are vertical extensometers, with odd numbers installed in the roof and even numbers installed in the floor. H 309 through H 316 are horizontal extensometers, with odd numbers installed in the pillar and even numbers installed in the rib. H 318 through H 321 and H 326 through H 329 are all diagonal extensometers. Extensometer H 317 was installed early from the room entry into the material that would become the pillar. This gage was installed at a height approximately 3/4 of the distance from the floor to the roof.

Extensometer data are presented in Tables 5.3.1a-y and Figures 5.3.1a-y.

The extensometer data present a wealth of information to the researcher that is not straightforward to interpret. As explained in Section 6.0, the time delay necessary for drilling emplacement holes and installing the extensometers results in unmeasured displacements that cannot be reconstructed readily. As a consequence, all remarks about these, as yet, unanalyzed extensometer records remain qualitative.

As with all displacement records, the extensometers show an increase in displacement rate when the heaters were activated. The increase is most pronounced for the gages in the pillar. Gages in the rib, although they show a response, have a much smaller increase. It can be shown through simple thermal expansion calculations that little of the measured increase in displacement results from heating of the wire or rod of the gage.

Several observations can be made about the measured extensometer displacements. Although these observations are evident from full-sized graphs contained in this section, they are very clearly shown in the reduced-size composite of Figure 2.3.1. Recall that for a principal station the extensometers and closure gages are physically linked. Visual inspection indicates two important aspects: (1) The floor and roof extensometer displacements are not equal. Displacements in the salt above the roof at a given depth are significantly larger than those in the salt beneath the floor at a comparable depth. There are two possible reasons for the noted differences. First, the floor contains a massive anhydrite layer that modifies the stress field and therefore the flow of the salt adjacent to the layer. Because of the perturbation of the anhydrite layer, in certain flow directions the measured salt displacements will be decreased. (2) The relative roof and floor displacements, and hence the relative salt displacements above the roof and below the floor, depend on the room geometry. Only a complete analysis can adequately quantify these effects.

Second, if <u>all</u> the deformation in the salt was measured by the extensometers and <u>all</u> the room closure was measured by the closure gage, which is known <u>not</u> to be the case, then a displacement balance could be performed across either the vertically or horizontally linked gages. In other words, the total salt displacement radially around the room must equal the radial closure of the room. Figure 2.3.1 shows a defect in the

Table 5.3.1 Extensometer Units (Gages) Location Guide

Station	Direction		Relative Location: pillar	center	rib
H ST135	Vertical	roof		H 301	
	Diagonal	45.0	H 318		H 320
	Diagonal				
	Horizontal	mid	H 309		H 310
	Diagonal				
	Diagonal	45.0	H 319		H 321
	Vertical	floor		H 302	
H ST225	Vertical	roof		H 303	
	Diagonal				
	Diagonal				
	Horizontal	mid	H 311		H 312
	Diagonal				
	Diagonal				
	Vertical	floor		H 304	
H ST315	Vertical	roof		H 305	
	Diagonal	45.0	H 326		H 328
	Diagonal				
	Horizontal	mid	H 313		H 314
	Diagonal				
	Diagonal	45.0	H 327		H 329
	Vertical	floor		H 306	
H ST045	Vertical	roof		H 307	
	Diagonal				
	Diagonal				
	Horizontal	mid	H 315		H 316
	Diagonal				
	Diagonal				
	Vertical	floor		H 308	
H ST090	Vertical	roof			
	Diagonal				
	Diagonal				
	Horizontal	3/4	H 317		
	Diagonal				
	Diagonal				
	Vertical	floor			

vertical displacement balance. A comparable defect exists in the horizontal displacement balance; however, it is not so apparent in the figure because of the large time differential between the installation of closure gage H 206 and the horizontal extensometers H 315 and H 316. The exact reason for this imbalance cannot be defined at the current state of analysis. The imbalance can originate from two sources. First, it is possible that the time dislocations in gage emplacements can produce unmeasured displacements that must be reconstructed in the data before a balance can be achieved. Second, and even more important, it is possible that the displacements in the salt extend deeper into the formation than the deepest anchor of the extensometer. Since it is known that the extent of the deformation field around the excavations may be greater than those expected in the design calculations for the placement of the deep anchors of the extensometers, it is highly probable that the defect in the balance is caused by unmeasured salt displacements in salt deeper than the deepest anchor. This subject, and the theoretical implications on analysis and design, are treated by Munson and Fossum [20].

Further comment on the extensometer results is possible only with detailed analysis. A word of caution: the user should read the PI Comments carefully since a few gages have quality problems and significant data reduction adjustments.

Table 5.3.1a. Extensometer Gages, H 301

Gage: H_301

****

***** H_301 PI Comments *****

08/07/87 DEM:DLH [RANK = 4(1),6(2),7(3),7(4),7(5)] THE DATA FROM THESE GAGES LEAVE SOMETHING TO BE DESIRED. GAGE 1 HAD SEVERE ELECTRICAL NOISE OR SCATTER PRIOR TO DAY 320. GAGES 2, 3, 4, AND 5 HAD MODERATE HYSTERESIS PRIOR TO DAY 320. THE ENTIRE UNIT WAS REINSTALLED AT DAY 320 AND THEREAFTER THE DATA ARE EXCELLENT, WITH A RANK OF 8 OR BETTER. [COMPRESSION = 3.18:1] (DEM)

***** H_301 Location *****

Principal Station 135
Station 135.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_301-1	EXT	P REM	V	10.96	10.88	135.00	135.69	1.46	16.70	1.56	16.80	SERATA	03/15/86	37-6465#04	
H_301-2	EXT	P REM	V	10.96	10.91	135.00	135.41	1.46	10.60	1.56	10.70	SERATA	03/15/86	37-6465#04	
H_301-3	EXT	P REM	V	10.96	10.94	135.00	135.22	1.46	6.33	1.56	6.44	SERATA	03/15/86	37-6465#04	
H_301-4	EXT	P REM	V	10.96	10.95	135.00	135.08	1.46	3.29	1.56	3.39	SERATA	03/15/86	37-6465#04	
H_301-5	EXT	P REM	V	10.96	10.96	135.00	135.05	1.46	2.37	1.56	2.47	SERATA	03/15/86	37-6465#04	

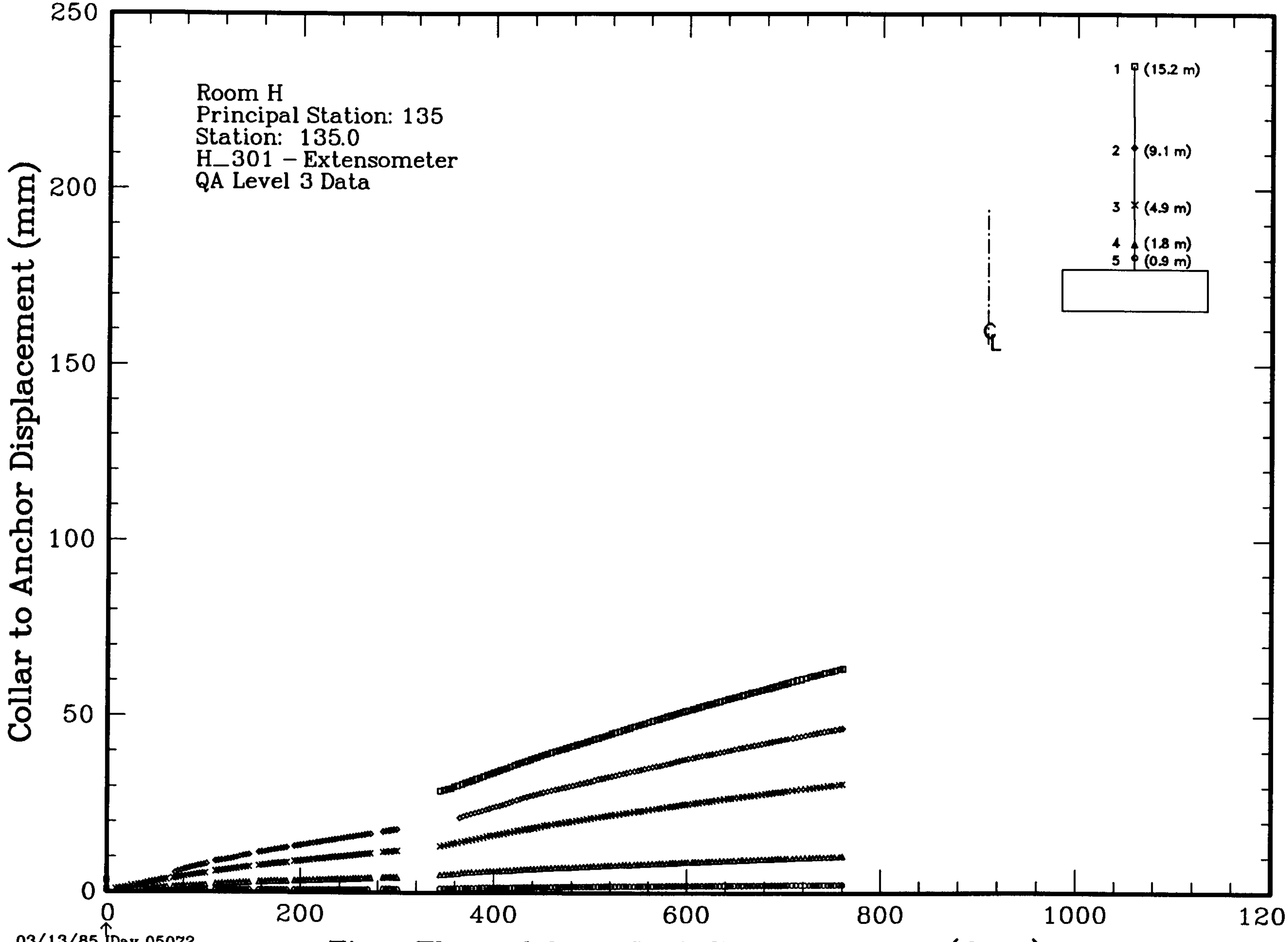

Figure 5.3.1a. Extensometer Gages, H 301

Table 5.3.1b. Extensometer Gages, H 302

Gage: H_302

****

***** H_302 PI Comments *****

08/07/87 DEM:DLH [RANK = 6(1),4(2),7(3),7(4),7(5)] THE DATA FROM THESE GAGES, WHILE HAVING SOME PROBLEMS, ARE GENERALLY VERY GOOD. GAGE 2 HAD SOME DIFFICULT NOISE AND HYSTERESIS PROBLEMS BETWEEN DAY 300 AND DAY 400 WHICH WERE NOT FULLY RESOLVED, AND WHICH ACCOUNTS FOR MOST OF THE LOW RANKING ASSIGNED TO THIS GAGE. ALL GAGES HAD MODERATE HYSTERESIS PRIOR TO DAY 400 AND THEREAFTER THE DATA ARE EXCELLENT, WITH A RANK OF 8 OR BETTER. [COMPRESSION = 8.35:1] (DEM)

***** H_302 Location *****

Principal Station 135
Station 134.9

								Gage Coordinates							
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_302-1	EXT	P REM	V	10.98	10.98	134.93	134.93	-1.46	-16.70	-1.35	-16.59	SERATA	03/13/85	37-6465#04	
H_302-2	EXT	P REM	V	10.98	10.98	134.93	134.93	-1.46	-10.60	-1.35	-10.50	SERATA	03/13/85	37-6465#04	
H_302-3	EXT	P REM	V	10.98	10.98	134.93	134.93	-1.46	-6.33	-1.35	-6.23	SERATA	03/13/85	37-6465#04	
H_302-4	EXT	P REM	V	10.98	10.98	134.93	134.93	-1.46	-3.29	-1.35	-3.18	SERATA	03/13/85	37-6465#04	
H_302-5	EXT	P REM	V	10.98	10.98	134.93	134.93	-1.46	-2.37	-1.35	-2.27	SERATA	03/13/85	37-6465#04	

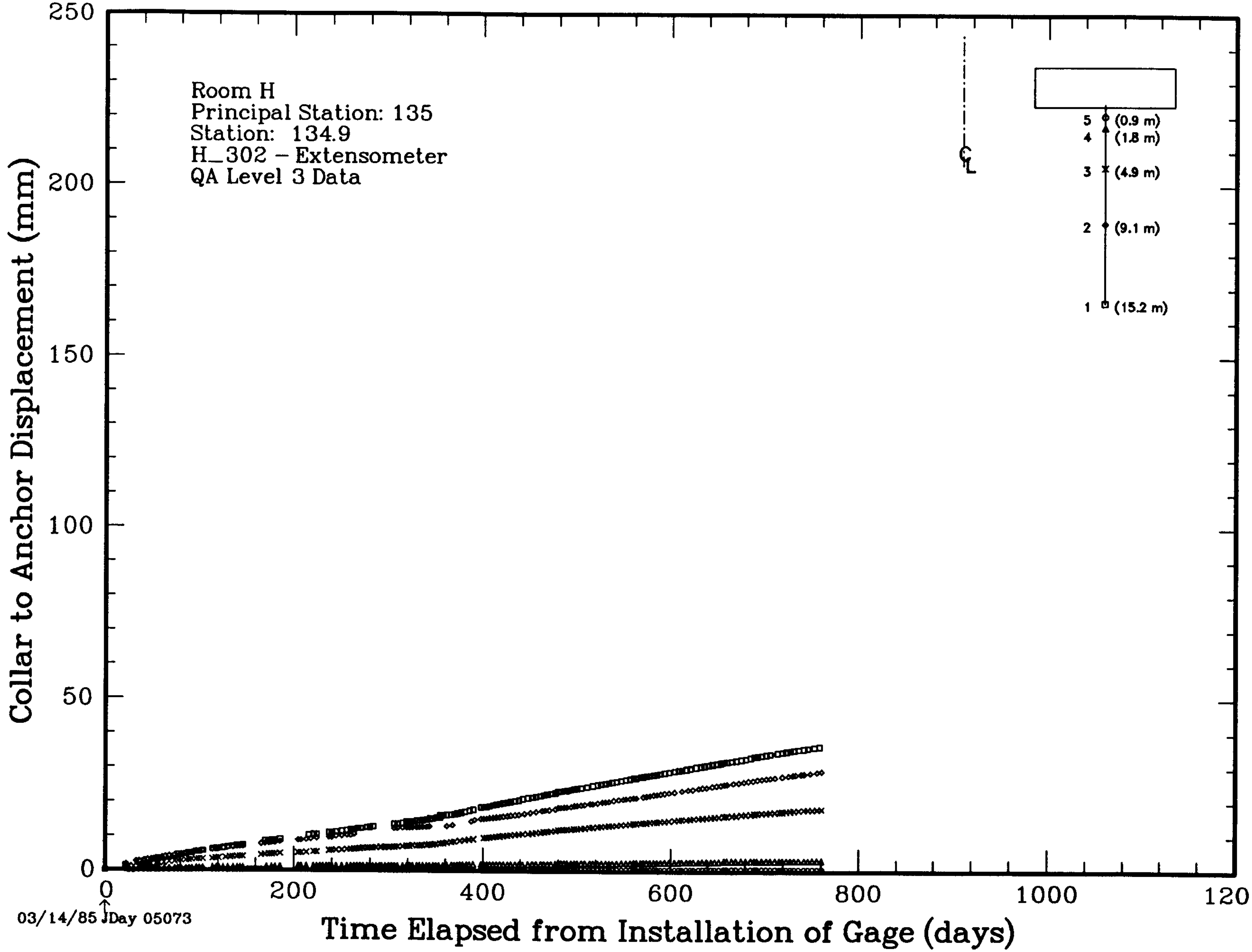

Figure 5.3.1b. Extensometer Gages, H 302

Table 5.3.1c. Extensometer Gages, H 303

Gage: H_303

****

***** H_303 PI Comments *****

08/14/87 DEM:DLH [RANK = 10(1),10(2),10(3),10(4),9(5)] ALL THE DATA OF THIS UNIT ARE OUTSTANDING, EXCEPT FOR GAGE 5 WHICH HAD HYSTERESIS DELETED JUST AFTER INITIAL INSTALLATION. THIS WAS ACTUALLY QUITE A MINOR CORRECTION. [COMPRESSION = 7.45:1] (DEM)

***** H_303 Location *****

Principal Station 225
Station 225.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_303-1	EXT	P REM	V	10.96	10.89	224.96	224.89	1.50	16.74	1.41	16.65	IRAD	03/14/85	37-6464#02	
H_303-2	EXT	P REM	V	10.96	10.92	224.96	224.92	1.50	10.64	1.41	10.56	IRAD	03/14/85	37-6464#02	
H_303-3	EXT	P REM	V	10.96	10.94	224.96	224.94	1.50	6.37	1.41	6.29	IRAD	03/14/85	37-6464#02	
H_303-4	EXT	P REM	V	10.96	10.95	224.96	224.96	1.50	3.33	1.41	3.24	IRAD	03/14/85	37-6464#02	
H_303-5	EXT	P REM	V	10.96	10.96	224.96	224.96	1.50	2.41	1.41	2.33	IRAD	03/14/85	37-6464#02	

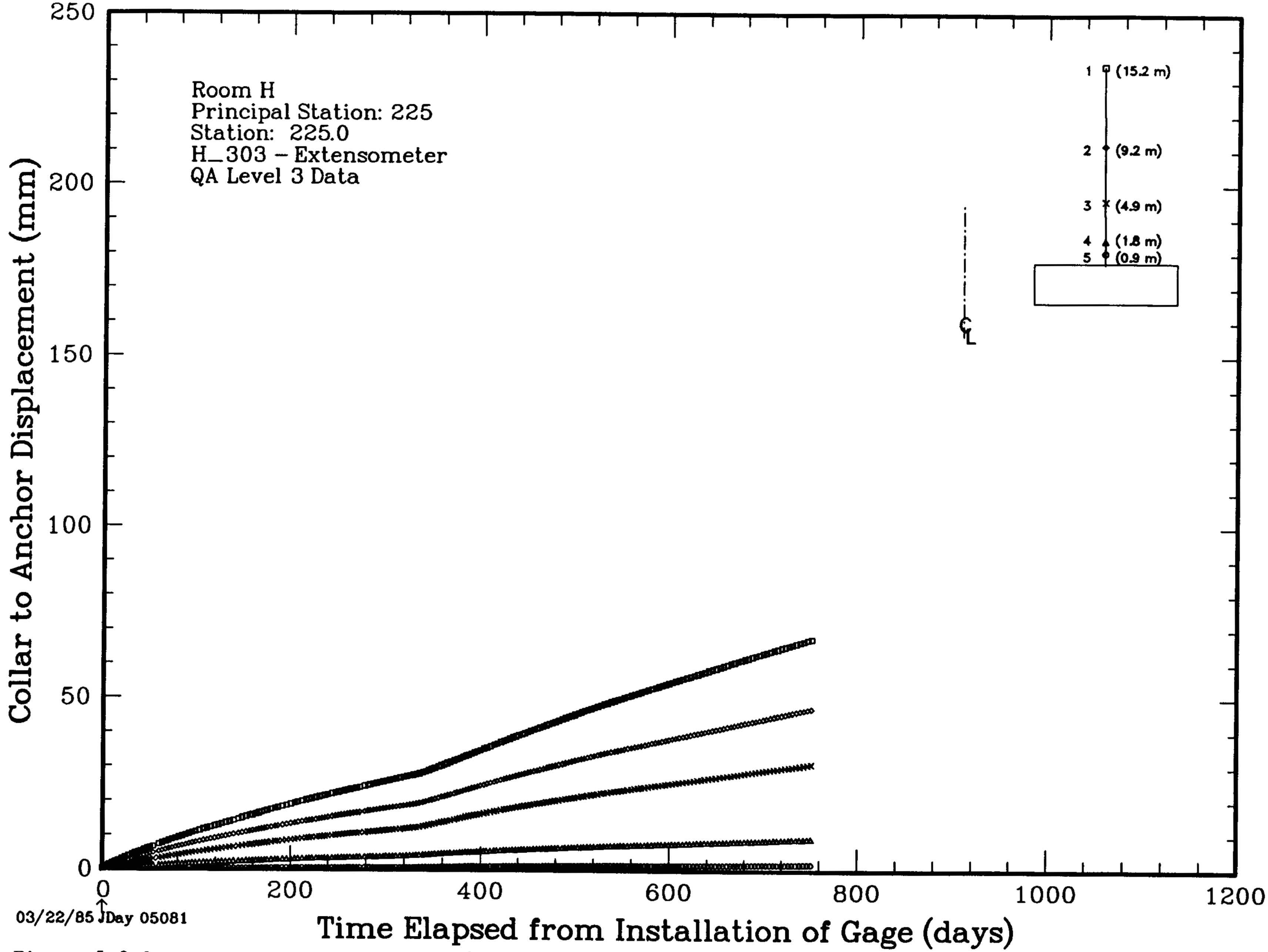

Figure 5.3.1c. Extensometer Gages, H 303

Table 5.3.1d. Extensometer Gages, H 304

Gage: H_304

****

***** H_304 PI Comments *****

08/14/87 DEM:DLH [RANK = 7(1),10(2),10(3),10(4),10(5)] THE DATA FOR ALL GAGES EXCEPT GAGE 1 ARE OUTSTANDING. GAGE 1 HAS A PECULIAR EARLY PHENOMENON THAT CAUSED SMALL STEPS IN THE DATA. THESE STEPS ARE SO SMALL (ABOUT 0.1 MM) THAT ON THE SCALE OF THE CURRENT TOTAL DISPLACEMENT THEY ARE NOT APPARENT. THE NATURE OF THE STEPS APPEARS TO BE A RECOVERY PROCESS SO THAT THE DISPLACEMENT AFTER THE STEP IS THE TRUE DISPLACEMENT OF THE GAGE. AS A CONSEQUENCE, NO CORRECTIONS FOR THE STEPS WERE MADE. HOWEVER, THE GAGE RANK HAD TO BE LOWERED TO REFLECT THE UNCERTAINTY CAUSED BY THE UNKNOWN, THOUGH MINOR, EFFECT. [COMPRESSION = 13.27:1] (DEM)

***** H_304 Location *****

Principal Station 225
Station 225.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_304-1	EXT	P REM	V	10.97	10.93	225.05	224.83	-1.50	-16.74	-1.58	-16.82	IRAD	03/21/85	37-6464#02	
H_304-2	EXT	P REM	V	10.97	10.95	225.05	224.92	-1.50	-10.64	-1.58	-10.72	IRAD	03/21/85	37-6464#02	
H_304-3	EXT	P REM	V	10.97	10.96	225.05	224.98	-1.50	-6.37	-1.58	-6.46	IRAD	03/21/85	37-6464#02	
H_304-4	EXT	P REM	V	10.97	10.97	225.05	225.03	-1.50	-3.33	-1.58	-3.41	IRAD	03/21/85	37-6464#02	
H_304-5	EXT	P REM	V	10.97	10.97	225.05	225.04	-1.50	-2.41	-1.58	-2.49	IRAD	03/21/85	37-6464#02	

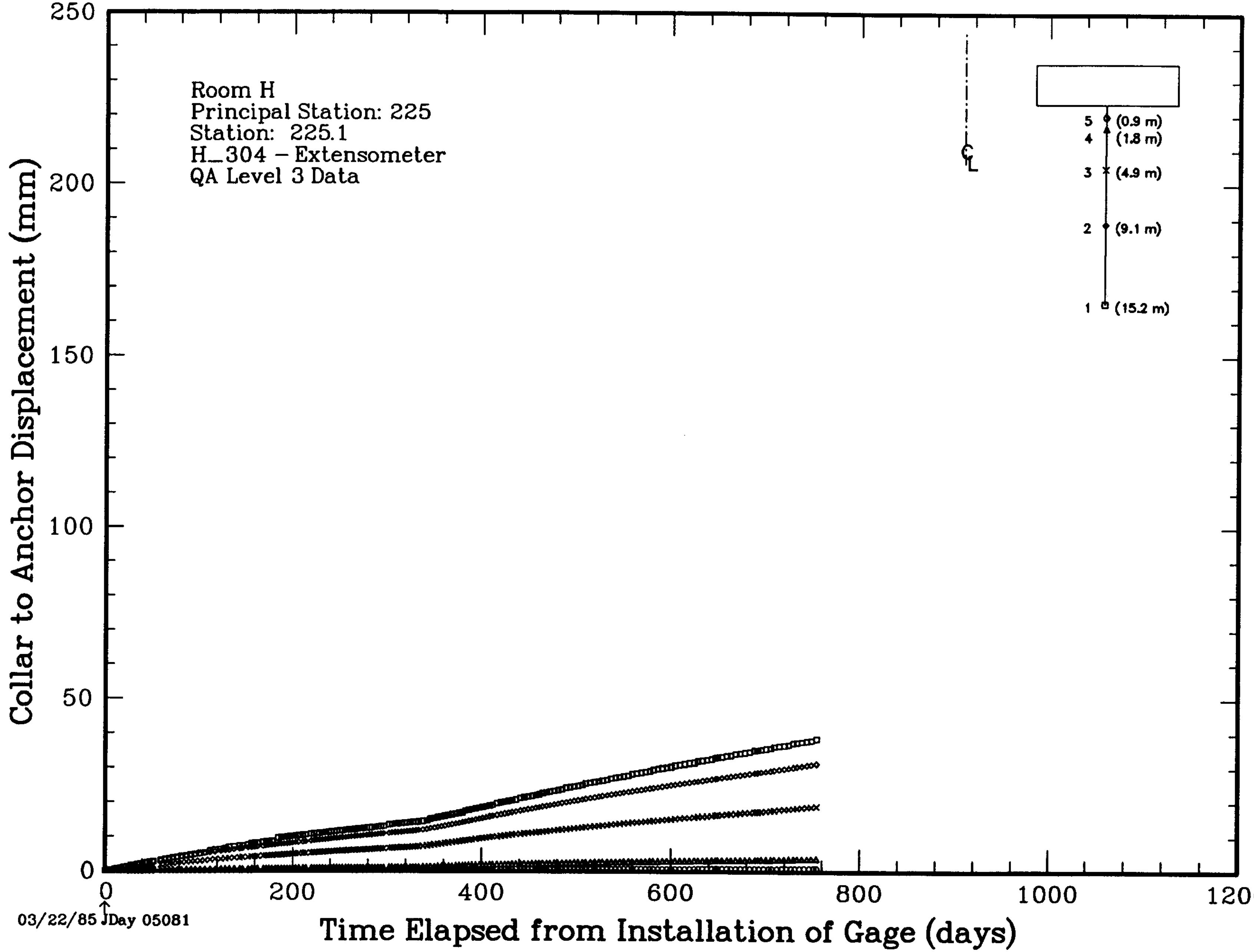

Figure 5.3.1d. Extensometer Gages, H 304

Table 5.3.1e. Extensometer Gages, H 305

Gage: H_305

****

***** H_305 PI Comments *****

08/14/87 DEM:DLH [RANK = 8(1),8(2),8(3),4(4),4(5)] THE DATA OF ALL GAGES WAS CORRECTED FOR MINOR HYSTERESIS EFFECTS, WHICH ACCOUNTED FOR THE RANKING. PRIOR TO REINSTALLATION AT DAY 316, THE DATA OF GAGE 4 AND 5 WERE APPARENTLY ERRATIC BECAUSE OF ELECTRICAL NOISE, POSSIBLY FROM CONTACT RESISTANCE. GAGE 5 WAS QUITE ERRATIC AT EARLY TIMES; WHILE THE REASON IS UNKNOWN, WIRE UNKINKING OR ANCHOR SLIPPAGE IS BELIEVED TO BE THE CAUSE. WHILE THE DATA OF THESE GAGES ARE EXCELLENT AFTER REINSTALLATION, THEIR DISPLACEMENT POSITION HAD TO BE REESTABLISHED FROM THE DATA OF UNITS H_303 AND H_307. [COMPRESSION = 4.12:1] (DEM)

***** H_305 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_305-1	EXT	P REM	V	10.97	11.00	315.03	314.95	1.42	16.66	1.34	16.58	SERATA	03/18/85	37-6465#04	
H_305-2	EXT	P REM	V	10.97	10.99	315.03	314.98	1.42	10.57	1.34	10.49	SERATA	03/18/85	37-6465#04	
H_305-3	EXT	P REM	V	10.97	10.98	315.03	315.00	1.42	6.30	1.34	6.22	SERATA	03/18/85	37-6465#04	
H_305-4	EXT	P REM	V	10.97	10.98	315.03	315.02	1.42	3.25	1.34	3.17	SERATA	03/18/85	37-6465#04	
H_305-5	EXT	P REM	V	10.97	10.98	315.03	315.02	1.42	2.34	1.34	2.26	SERATA	03/18/85	37-6465#04	

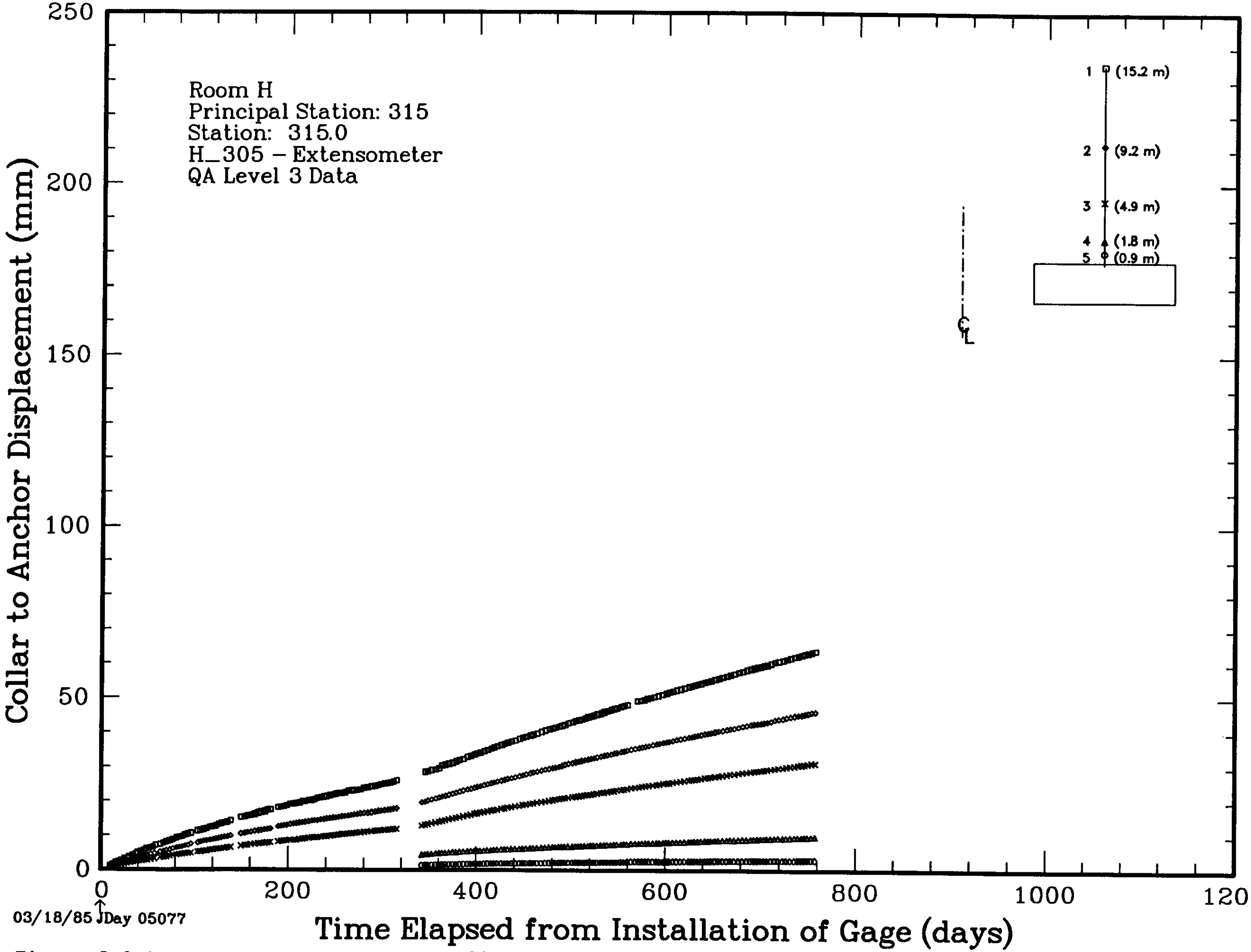

Figure 5.3.1e. Extensometer Gages, H 305

Table 5.3.1f. Extensometer Gages, H 306

Gage: H_306

****

***** H_306 PI Comments *****

08/14/87 DEM:DLH [RANK = 7(1),7(2),8(3),7(2),6(5)] ALL OF THE GAGES SUFFERED FROM AN EARLY HYSTERESIS WHICH HAD TO BE CORRECTED. TWO LATER HYSTERESIS EVENTS CAUSED 20 DAY AMOUNTS OF DATA TO BE DELETED; HOWEVER, THIS LATER HYSTERESIS DID NOT DETRACT FROM DATA QUALITY SO THAT THE RECORDS ARE QUITE GOOD. GAGE 5 HAD MAJOR AMOUNTS OF ELECTRICAL NOISE BETWEEN DAY 190 AND 320; THE DELETION OF THESE DATA RESULTED IN THE RANKING GIVEN EVEN THOUGH THE TOTAL DISPLACEMENTS ARE ACCURATE. [COMPRESSION = 11.86:1] (DEM)

***** H_306 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_306-1	EXT	P REM	V	10.96	10.76	315.03	314.97	-1.42	-16.73	-1.50	-16.81	SERATA	03/13/85	37-6465#04	
H_306-2	EXT	P REM	V	10.96	10.84	315.03	315.00	-1.42	-10.57	-1.50	-10.65	SERATA	03/13/85	37-6465#04	
H_306-3	EXT	P REM	V	10.96	10.90	315.03	315.00	-1.42	-6.30	-1.50	-6.38	SERATA	03/13/85	37-6465#04	
H_306-4	EXT	P REM	V	10.96	10.94	315.03	315.02	-1.42	-3.25	-1.50	-3.33	SERATA	03/13/85	37-6465#04	
H_306-5	EXT	P REM	V	10.96	10.95	315.03	315.03	-1.42	-2.34	-1.50	-2.42	SERATA	03/13/85	37-6465#04	

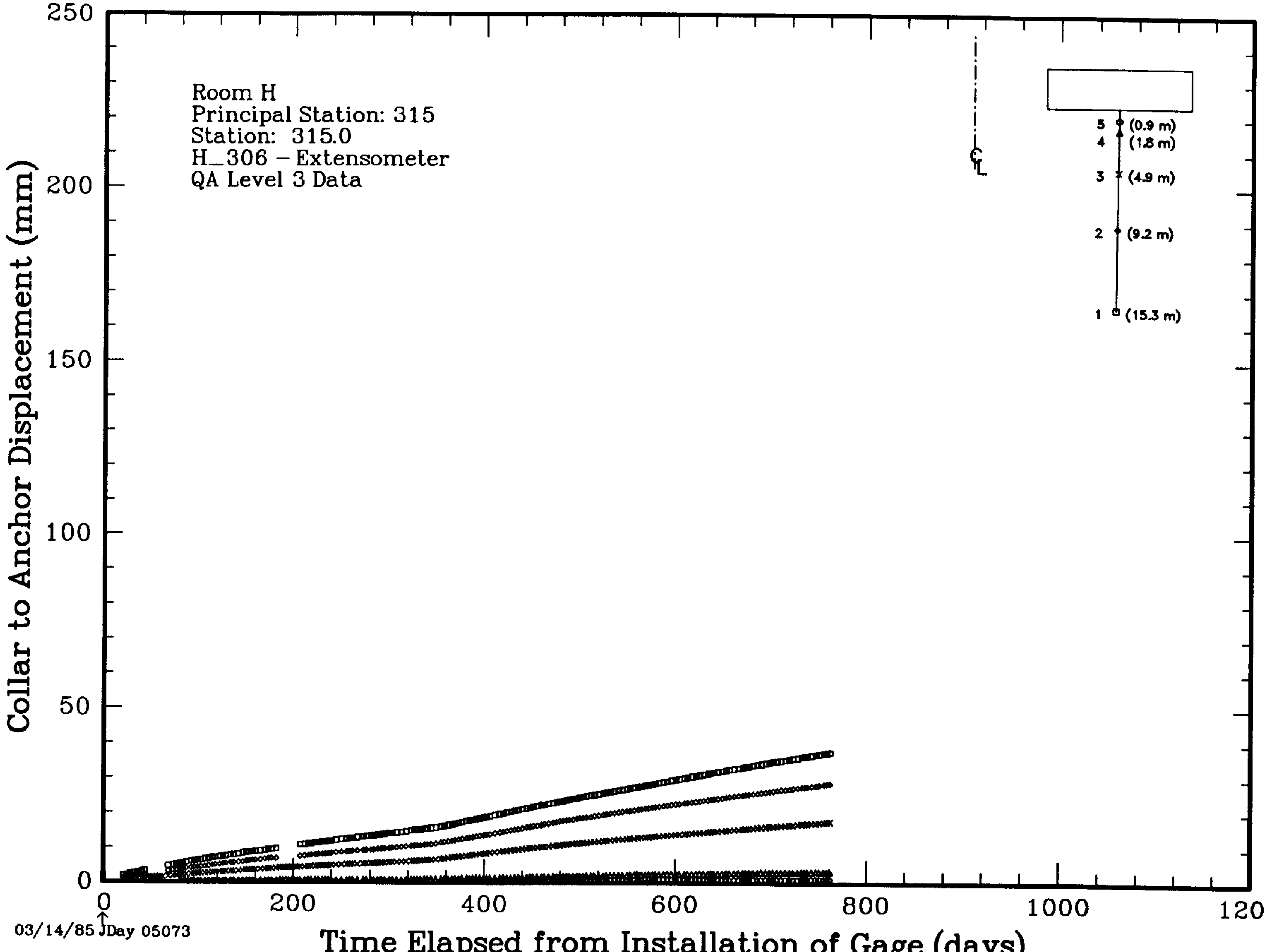

Figure 5.3.1f. Extensometer Gages, H 306

Table 5.3.1g. Extensometer Gages, H 307

Gage: H_307

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***** H_307 PI Comments *****

08/14/87 DEM:DLH [RANK = 10(1),10(2),10(3),10(4),10(5)] ALL THE DATA OF THESE GAGES ARE OUTSTANDING, WITH VIRTUALLY NO CORRECTIONS NECESSARY TO THE DATA. [COMPRESSION = 7.49:1] (DEM)

***** H_307 Location *****

Principal Station 045
Station 45.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_307-1	EXT	P REM	V	10.98	10.92	44.96	45.13	1.47	16.71	1.54	16.78	IRAD	03/20/85	37-6464#02	
H_307-2	EXT	P REM	V	10.98	10.94	44.96	45.06	1.47	10.62	1.54	10.68	IRAD	03/20/85	37-6464#02	
H_307-3	EXT	P REM	V	10.98	10.96	44.96	45.00	1.47	6.35	1.54	6.41	IRAD	03/20/85	37-6464#02	
H_307-4	EXT	P REM	V	10.98	10.97	44.96	44.97	1.47	3.30	1.54	3.36	IRAD	03/20/85	37-6464#02	
H_307-5	EXT	P REM	V	10.98	10.97	44.96	44.97	1.47	2.39	1.54	2.45	IRAD	03/20/85	37-6464#02	

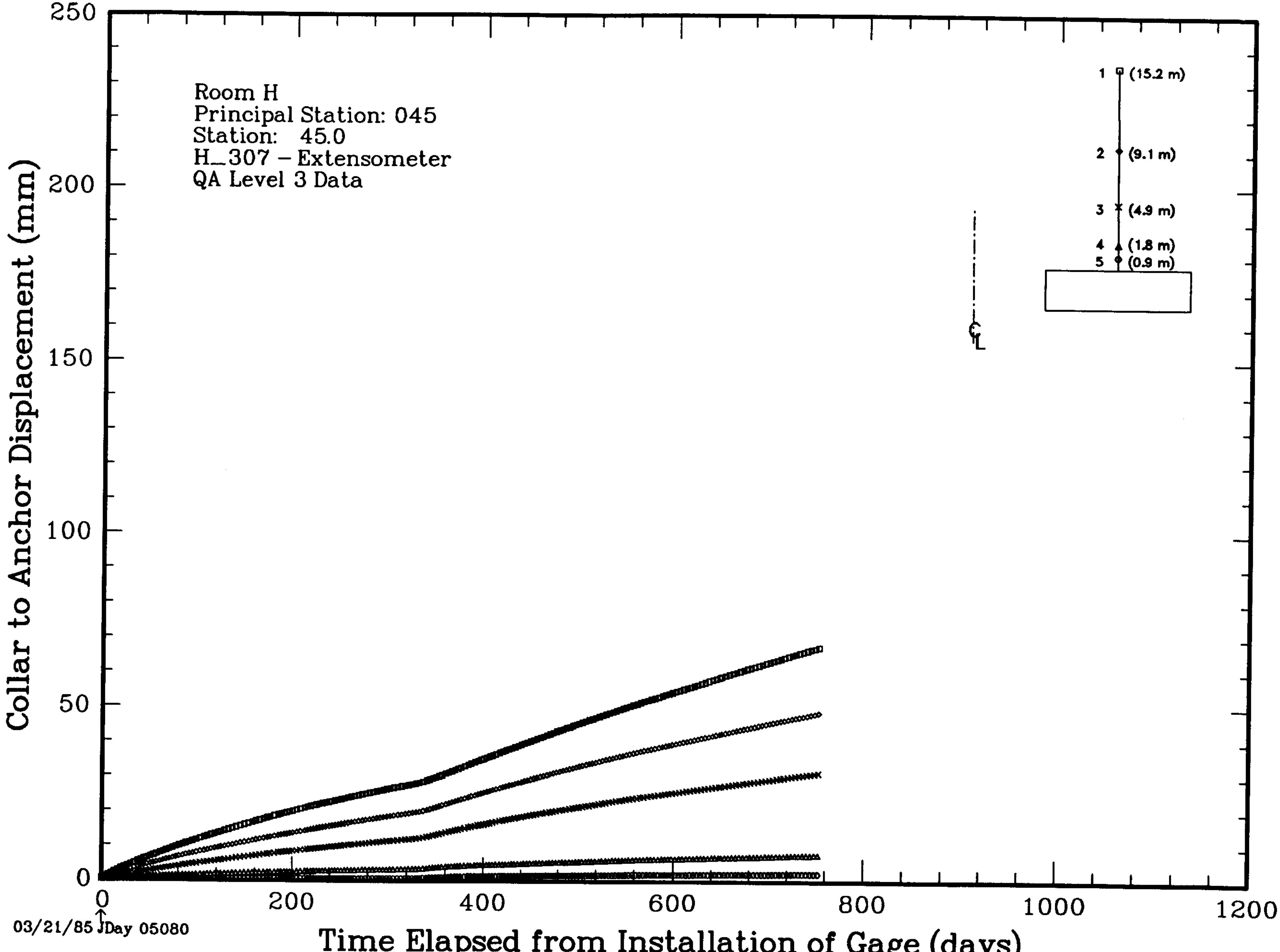

Figure 5.3.1g. Extensometer Gages, H 307

Table 5.3.1h. Extensometer Gages, H 308

Gage: H_308

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***** H_308 PI Comments *****

08/14/87 DEM:DLH [RANK = 10(1),10(2),10(3),10(4),10(5)] ALL THE DATA FOR THIS UNIT ARE OUTSTANDING. [COMPRESSION = 12.44:1] (DEM)

***** H_308 Location *****

Principal Station 045
Station 44.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_308-1	EXT	P REM	V	10.99	11.11	44.93	44.77	-1.47	-16.71	-1.41	-16.65	IRAD	03/20/85	37-6464#02	
H_308-2	EXT	P REM	V	10.99	11.06	44.93	44.84	-1.47	-10.62	-1.41	-10.55	IRAD	03/20/85	37-6464#02	
H_308-3	EXT	P REM	V	10.99	11.03	44.93	44.88	-1.47	-6.35	-1.41	-6.28	IRAD	03/20/85	37-6464#02	
H_308-4	EXT	P REM	V	10.99	11.01	44.93	44.92	-1.47	-3.30	-1.41	-3.24	IRAD	03/20/85	37-6464#02	
H_308-5	EXT	P REM	V	10.99	11.00	44.93	44.92	-1.47	-2.39	-1.41	-2.33	IRAD	03/20/85	37-6464#02	

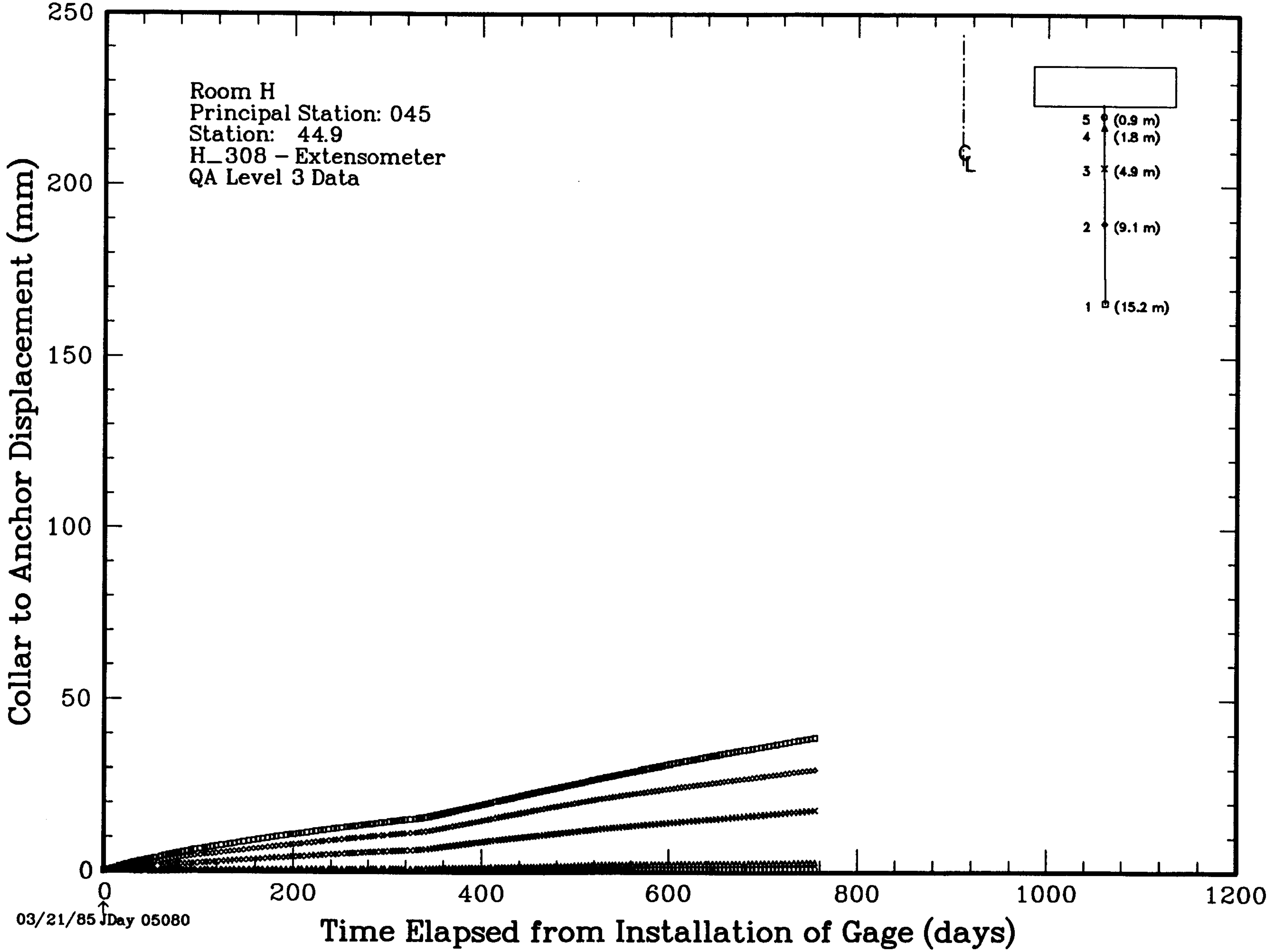

Figure 5.3.1h. Extensometer Gages, H 308

Table 5.3.1i. Extensometer Gages, H 309

Gage: H_309

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***** H_309 PI Comments *****

08/07/87 DLH [RANK = 9(1),9(2),8(3),9(4)] MOST OF THESE DATA ARE EXCEPTIONAL. GAGE 2 HAD ELECTRICAL NOISE PROBLEMS BETWEEN DAY 110 AND DAY 150 WHICH DID NOT AFFECT THE REMAINING DATA. GAGE 3 HAS BEEN DISCONTINUED AFTER DAY 565 BECAUSE OF A BROKEN GAGE FIXTURE. THERE WERE TWO EXTENTION INSTALLATIONS ON THIS UNIT. VIRTUALLY NO HYSTERESIS OCCURRED ON THE GAGE DATA. [COMPRESSION 3.97:1] (DEM)

***** H_309 Location *****

Principal Station 135
Station 134.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_309-1	EXT	P REM	H	5.60	0.11	134.86	129.91	0.06	0.07	0.17	0.17	SERATA	03/11/85	37-6465#06	
H_309-2	EXT	P REM	H	5.60	2.55	134.86	134.69	0.06	0.07	0.17	0.17	SERATA	03/11/85	37-6465#06	
H_309-3	EXT	P REM	H	5.60	3.77	134.86	134.79	0.06	0.07	0.17	0.17	SERATA	03/11/85	37-6465#06	
H_309-4	EXT	P REM	H	5.60	4.68	134.86	134.83	0.06	0.06	0.17	0.17	SERATA	03/11/85	37-6465#06	

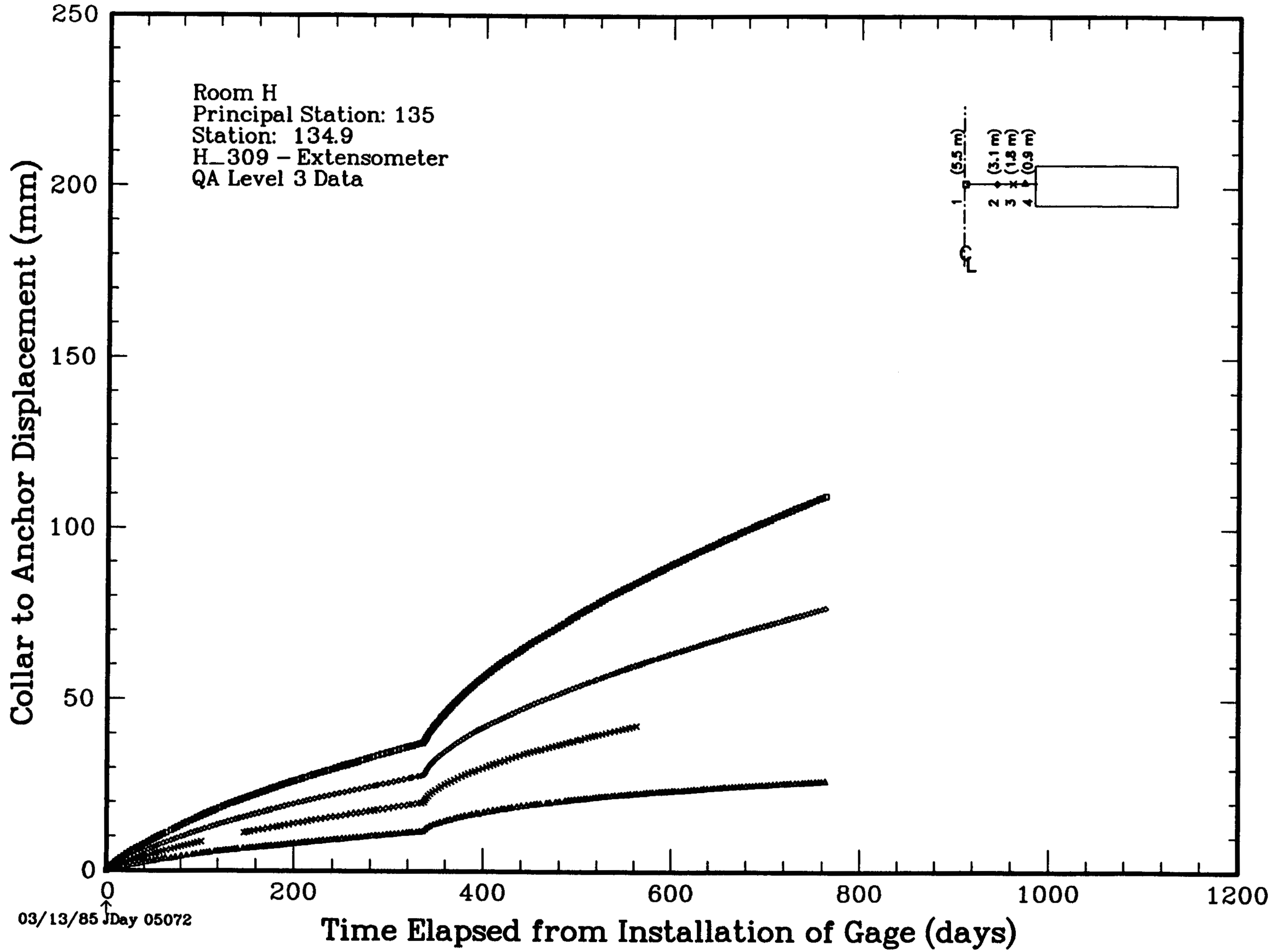

Figure 5.3.1i. Extensometer Gages, H 309

Table 5.3.1j. Extensometer Gages, H 310

Gage: H_310

****

***** H_310 PI Comments *****

08/11/87 DLH [RANK = 0(1),0(2),8(3),6(4),8(5)] MOST OF THE DATA FOR GAGES 3, 4, AND 5 ARE EXCELLENT; HOWEVER, GAGE 4 HAD A PERIOD OF TIME BETWEEN DAY 472 AND 616 WITH ELECTRONIC SCATTER THAT HAD TO BE REMOVED, TO REDUCE THE OVERALL RANKING FOR THE GAGE. THE APPARENT LINKING OF THE WIRES OF GAGES 1 AND 2 COULD NOT BE RESOLVED TO INDICATE IF EITHER GAGE WAS GIVING CORRECT READINGS; THEREFORE, EVEN THOUGH THE QUALITY WAS ADEQUATE BOTH GAGES HAD TO BE ELIMINATED BY THE PRINCIPAL INVESTIGATOR. THIS IS EQUIVALENT TO THE 0 RANK FOR THESE GAGES. [COMPRESSION 9.45:1] (DEM)

***** H_310 Location *****

Principal Station 135
Station 135.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_310-1	EXT	P REM	H	16.34	31.58	134.97	134.88	0.07	0.01	0.17	0.11	SERATA	03/13/85	37-6465#04	
H_310-2	EXT	P REM	H	16.34	25.48	134.97	134.88	0.07	0.05	0.17	0.16	SERATA	03/13/85	37-6465#04	
H_310-3	EXT	P REM	H	16.34	21.21	134.97	134.91	0.07	0.06	0.17	0.16	SERATA	03/13/85	37-6465#04	
H_310-4	EXT	P REM	H	16.34	18.16	134.97	134.95	0.07	0.06	0.17	0.17	SERATA	03/13/85	37-6465#04	
H_310-5	EXT	P REM	H	16.34	17.25	134.97	134.96	0.07	0.07	0.17	0.17	SERATA	03/13/85	37-6465#04	

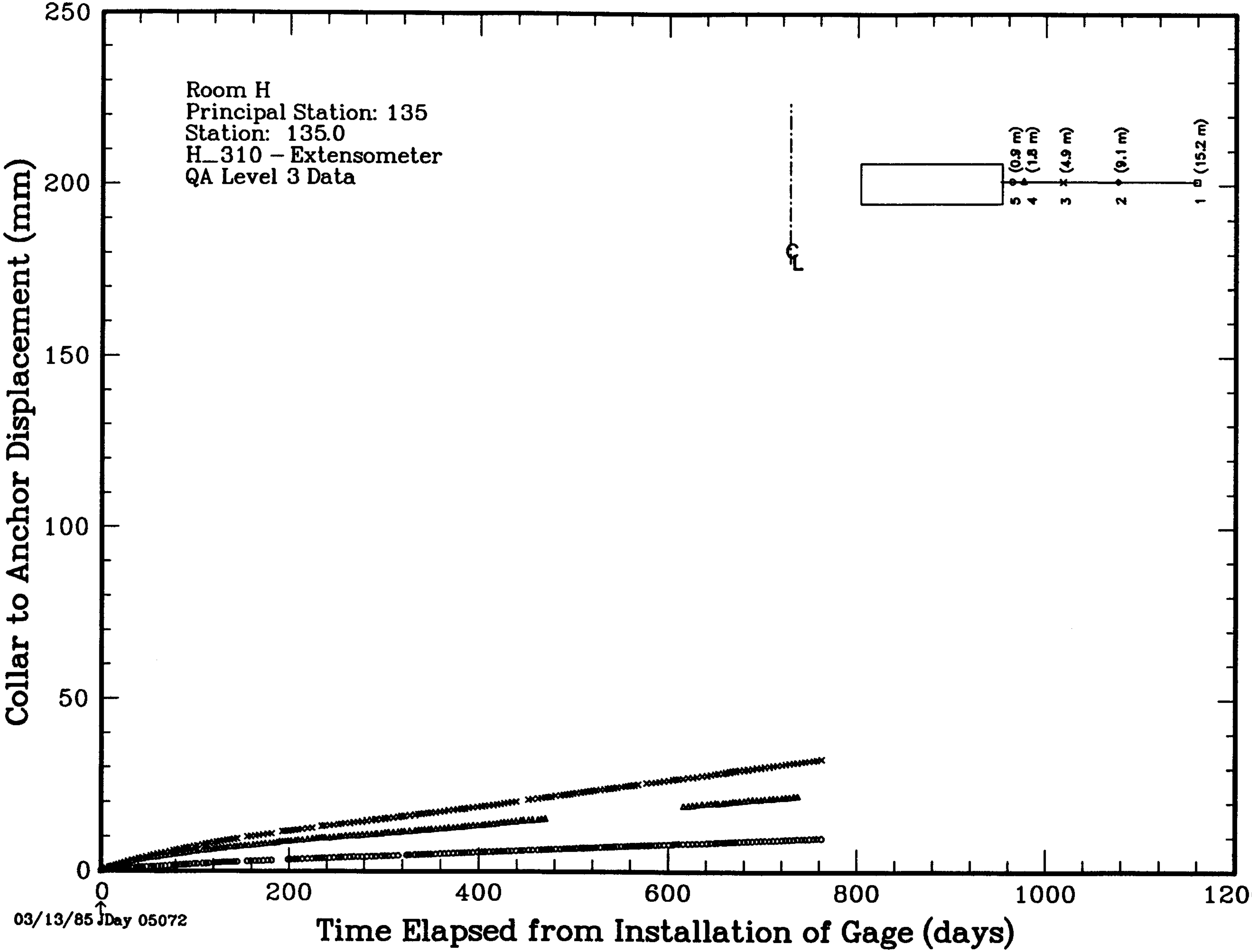

Figure 5.3.1j. Extensometer Gages, H 310

Table 5.3.1k. Extensometer Gages, H 311

Gage: H_311

****

***** H_311 PI Comments *****

08/14/87 DLH [RANK = 8(1),9(2),9(3),8(4)] EXCEPT FOR GAGE 1 AND 4, THE DATA FOR THIS UNIT ARE EXCEPTIONAL. DELETIONS IN GAGE 1 AND 4 DATA WERE DUE TO ELECTRICAL NOISE. THE UNIT WAS REINSTALLED TWICE BUT THE CORRECTIONS WERE VERY STRAIGHT FORWARD. [COMPRESSION = 3.03:1] (DEM)

***** H_311 Location *****

Principal Station 225
Station 225.0

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_311-1	EXT	P REM	H	5.57	0.39	224.97	222.65	-0.05	-0.05	-0.13	-0.13	IRAD	03/19/85	37-6464#04	
H_311-2	EXT	P REM	H	5.57	2.53	224.97	224.73	-0.05	-0.05	-0.13	-0.13	IRAD	03/19/85	37-6464#04	
H_311-3	EXT	P REM	H	5.57	3.74	224.97	224.89	-0.05	-0.05	-0.13	-0.13	IRAD	03/19/85	37-6464#04	
H_311-4	EXT	P REM	H	5.57	4.66	224.97	224.96	-0.05	-0.05	-0.13	-0.13	IRAD	03/19/85	37-6464#04	

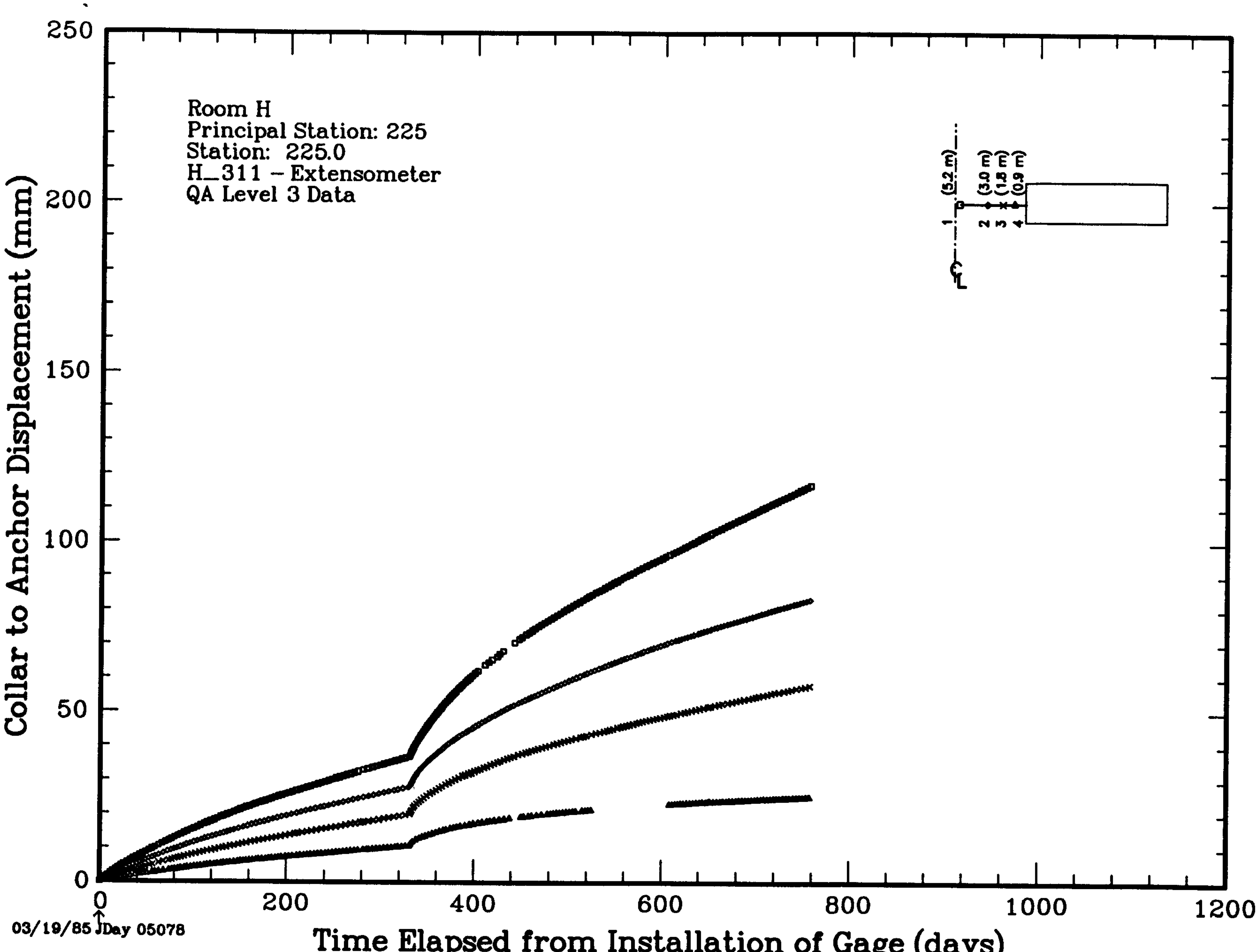

Figure 5.3.1k. Extensometer Gages, H 311

Table 5.3.11. Extensometer Gages, H 312

Gage: H_312

****

***** H_312 PI Comments *****

08/16/87 DLH [RANK = 10(1),10(2),10(3),10(4),10(5)] THE GAGES OF THIS UNIT ARE OF OUTSTANDING QUALITY, ONLY LEVEL 2 DELETIONS OF THE FEW ERRONEOUS DATUM CAUSED BY SITE POWER PROBLEMS WERE NECESSARY. [COMPRESSION = 12.08:1] (DEM)

***** H_312 Location *****

Principal Station 225
Station 225.0

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_312-1	EXT	P REM	H	16.37	31.62	224.98	224.94	-0.07	-0.06	-0.16	-0.15	IRAD	03/18/85	37-6464#02	
H_312-2	EXT	P REM	H	16.37	25.52	224.98	224.95	-0.07	-0.07	-0.16	-0.15	IRAD	03/18/85	37-6464#02	
H_312-3	EXT	P REM	H	16.37	21.25	224.98	224.96	-0.07	-0.07	-0.16	-0.16	IRAD	03/18/85	37-6464#02	
H_312-4	EXT	P REM	H	16.37	18.20	224.98	224.97	-0.07	-0.07	-0.16	-0.16	IRAD	03/18/85	37-6464#02	
H_312-5	EXT	P REM	H	16.37	17.29	224.98	224.98	-0.07	-0.07	-0.16	-0.16	IRAD	03/18/85	37-6464#02	

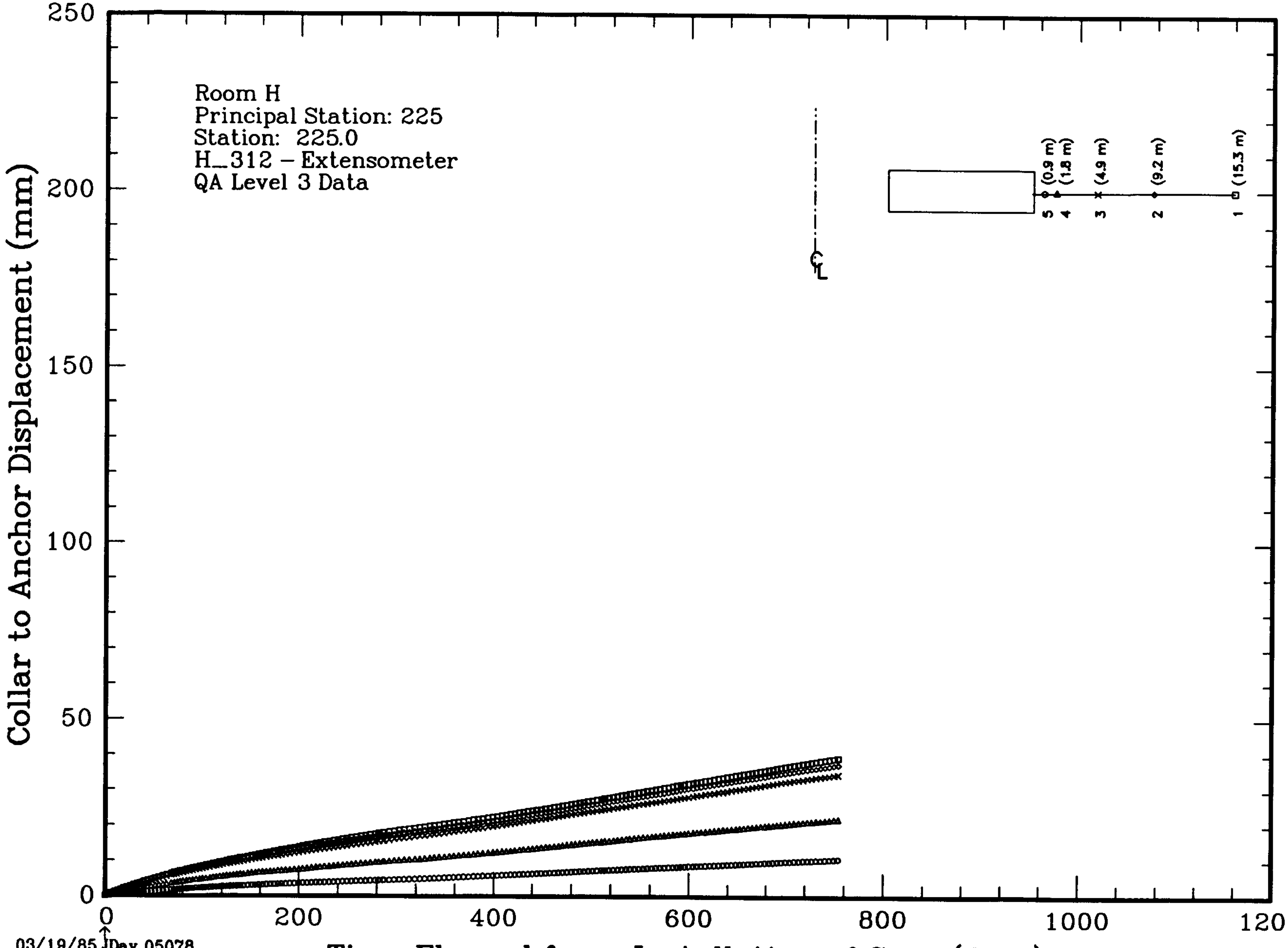

Figure 5.3.11. Extensometer Gages, H 312

Table 5.3.1m. Extensometer Gages, H 313

Gage: H_313

****

***** H_313 PI Comments *****

09/20/87 DLH [RANK = 6(1),9(2),9(3),9(4)] THE DATA OF ALL THESE GAGES ARE EXCEPTIONAL; HOWEVER, GAGE 1 HAD TO BE GIVEN A LOWER RANK BECAUSE THIS GAGE INADVERTENTLY REMAINED ELECTRICALLY DISCONNECTED FOR THE FIRST 100 DAYS. THE DISPLACEMENT FOR GAGE 1 WAS ESTIMATED AT 100 DAYS IN PROPORTION TO THE DISPLACEMENTS OF THE OTHER GAGES. [COMPRESSION RATIO = 4.31:1] (DEM)

***** H_313 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_313-1	EXT	P REM	H	5.59	0.11	315.05	322.48	0.00	0.01	-0.08	-0.07	SERATA	03/11/85	37-6465#06	
H_313-2	EXT	P REM	H	5.59	2.55	315.05	315.22	0.00	0.01	-0.08	-0.07	SERATA	03/11/85	37-6465#06	
H_313-3	EXT	P REM	H	5.59	3.77	315.05	315.15	0.00	0.00	-0.08	-0.08	SERATA	03/11/85	37-6465#06	
H_313-4	EXT	P REM	H	5.59	4.68	315.05	315.06	0.00	0.00	-0.08	-0.08	SERATA	03/11/85	37-6465#06	

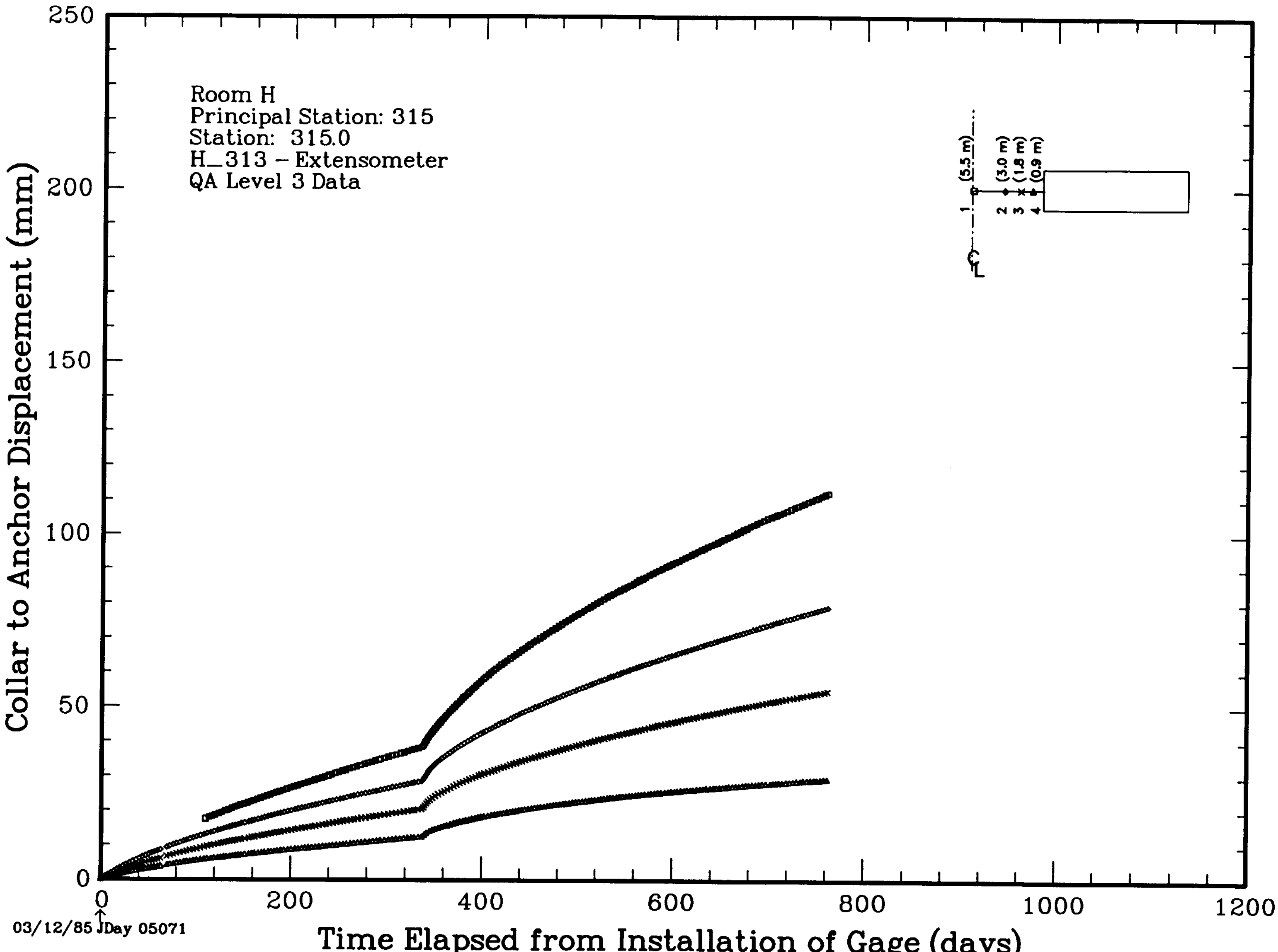

Figure 5.3.1m. Extensometer Gages, H 313

Table 5.3.1n. Extensometer Gages, H 314

Gage: H_314

****

***** H_314 PI Comments *****

08/16/87 DLH [RANK = 8(1),8(2),8(3),7(4),9(5)] GAGES 1, 2, AND 3 ALL HAVE EXCELLENT QUALITY, WITH ONLY MINOR HYSTERESIS DELETED FROM THE RECORDS. GAGE 4 DATA SHOWED ELECTRICAL NOISE BETWEEN DAY 522 AND 617; THE DATA IN THIS INTERVAL WERE DELETED. GAGE 5 DATA WERE EXCEPTIONAL. THE UNIT WAS REINSTALLED ONCE, WITH ASSOCIATED SIMPLE SHIFTS. [COMPRESSION = 9.84:1] (DEM)

***** H_314 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_314-1	EXT	P REM	H	16.36	31.60	314.99	315.00	0.00	-0.02	-0.08	-0.11	SERATA	03/12/85	37-6465#04	
H_314-2	EXT	P REM	H	16.36	25.50	314.99	315.00	0.00	-0.02	-0.08	-0.10	SERATA	03/12/85	37-6465#04	
H_314-3	EXT	P REM	H	16.36	21.23	314.99	314.99	0.00	-0.01	-0.08	-0.09	SERATA	03/12/85	37-6465#04	
H_314-4	EXT	P REM	H	16.36	18.18	314.99	314.99	0.00	0.00	-0.08	-0.09	SERATA	03/12/85	37-6465#04	
H_314-5	EXT	P REM	H	16.36	17.27	314.99	314.99	0.00	0.00	-0.08	-0.08	SERATA	03/12/85	37-6465#04	

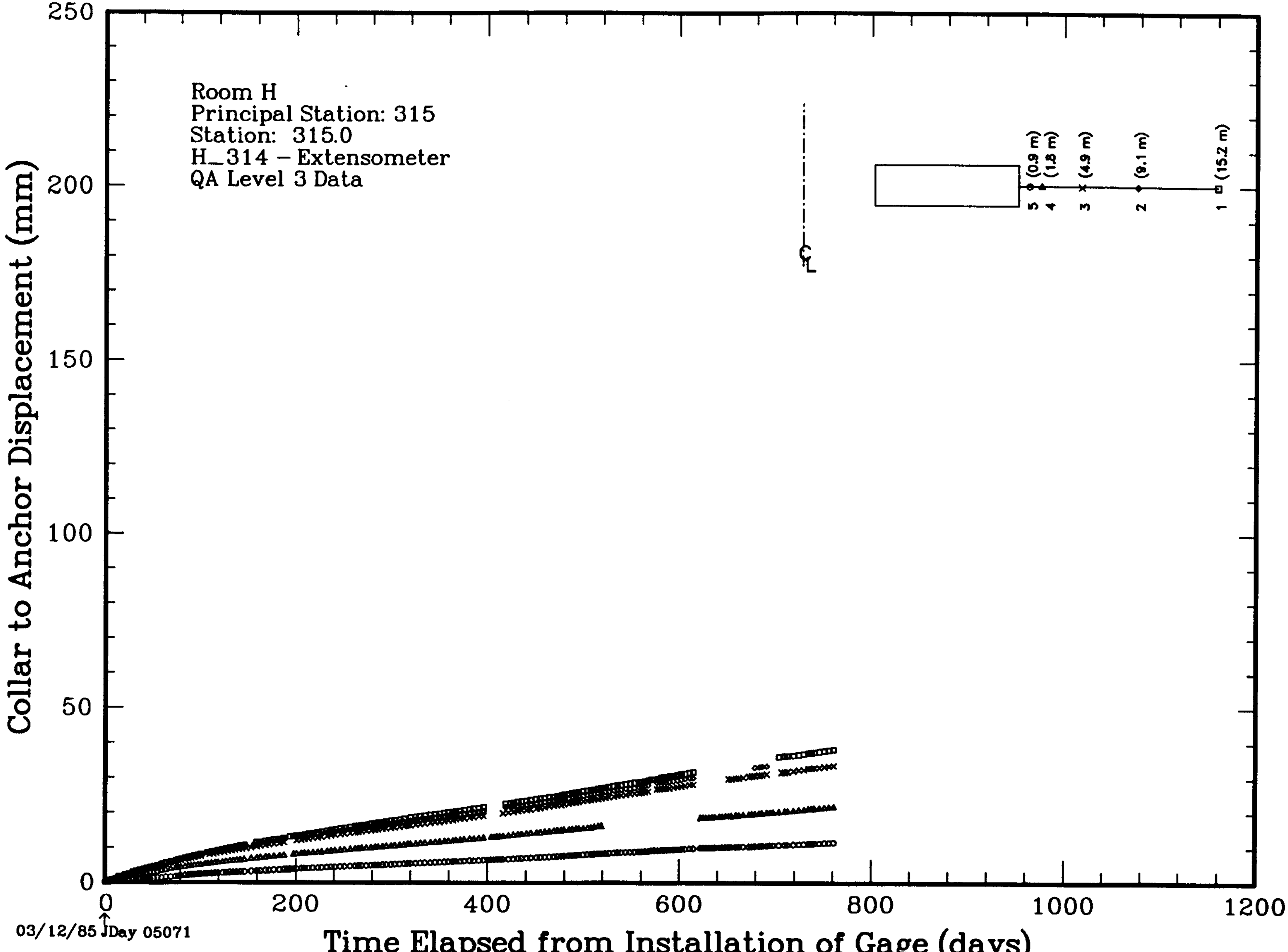

Figure 5.3.1n. Extensometer Gages, H 314

Table 5.3.1o. Extensometer Gages, H 315

Gage: H_315

****

***** H_315 PI Comments *****

08/14/87 DLH [RANK = 8(1),8(2),8(3),8(4)] THE DATA OF THIS UNIT ARE ALL EXCELLENT. THERE WAS ONE REINSTALLATION AND SOME MINOR SHIFTS, WHICH WERE EASILY CORRECTED. [COMPRESSION = 4.37:1] (DEM)

***** H_315 Location *****

Principal Station 045
Station 45.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_315-1	EXT	P REM	H	5.56	0.38	44.95	36.41	-0.07	-0.09	-0.01	-0.03	IRAD	03/19/85	37-6464#04	
H_315-2	EXT	P REM	H	5.56	2.48	44.95	44.88	-0.07	-0.09	-0.01	-0.02	IRAD	03/19/85	37-6464#04	
H_315-3	EXT	P REM	H	5.56	3.72	44.95	44.92	-0.07	-0.08	-0.01	-0.02	IRAD	03/19/85	37-6464#04	
H_315-4	EXT	P REM	H	5.56	4.64	44.95	44.93	-0.07	-0.07	-0.01	-0.01	IRAD	03/19/85	37-6464#04	

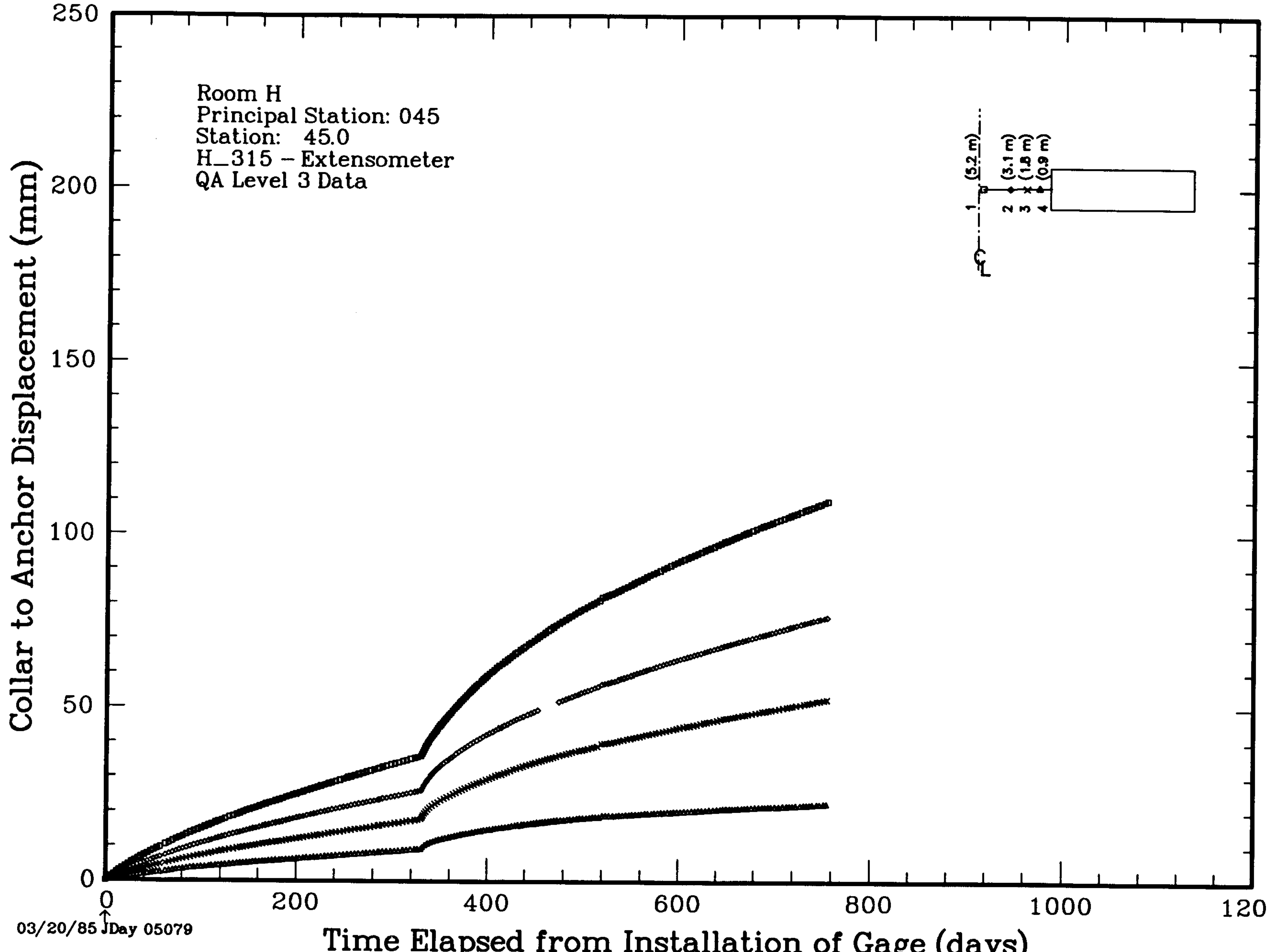

Figure 5.3.1o. Extensometer Gages, H 315

Table 5.3.1p. Extensometer Gages, H 316

Gage: H_316

****

***** H_316 PI Comments *****

09/20/87 DLH [RANK = 10(1),10(2),10(3),10(4)] THE DATA FROM THIS UNIT ARE OUTSTANDING, WITH VIRTUALLY NO CORRECTIONS. [COMPRESSION = 9.05:1] (DEM)

***** H_316 Location *****

Principal Station 045
Station 45.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_316-1	EXT	P REM	H	16.40	31.64	45.03	45.02	-0.06	-0.06	0.00	0.00	IRAD	03/19/85	37-6464#02	
H_316-2	EXT	P REM	H	16.40	25.54	45.03	45.02	-0.06	-0.06	0.00	0.00	IRAD	03/19/85	37-6464#02	
H_316-3	EXT	P REM	H	16.40	21.28	45.03	45.02	-0.06	-0.06	0.00	0.00	IRAD	03/19/85	37-6464#02	
H_316-4	EXT	P REM	H	16.40	18.23	45.03	45.03	-0.06	-0.06	0.00	0.00	IRAD	03/19/85	37-6464#02	
H_316-5	EXT	P REM	H	16.40	17.32	45.03	45.03	-0.06	-0.06	0.00	0.00	IRAD	03/19/85	37-6464#02	

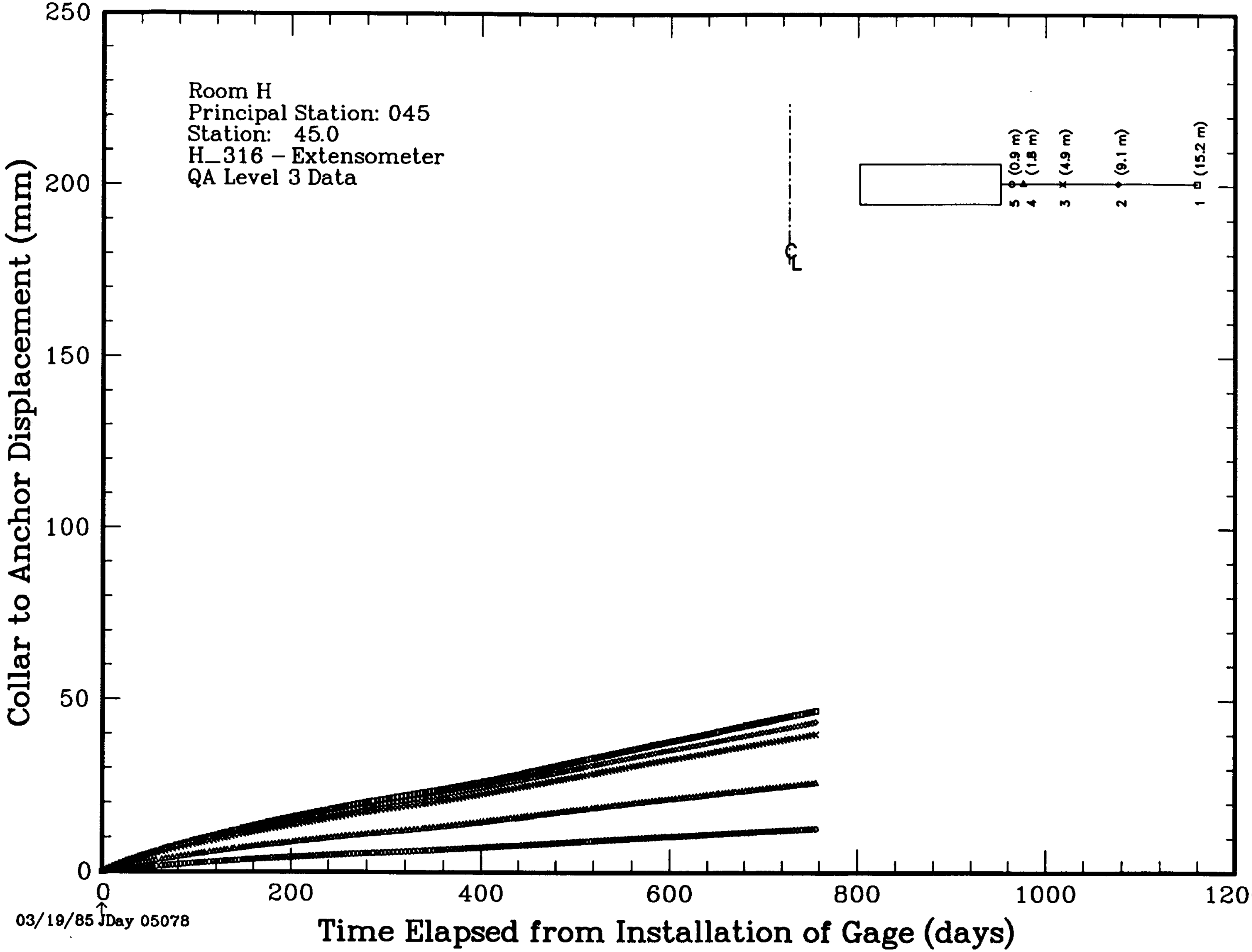

Figure 5.3.1p. Extensometer Gages, H 316

Table 5.3.1q. Extensometer Gages, H 317

Gage: H_317

****

***** H_317 PI Comments *****

08/14/87 DLH:DEM [RANK = 8(1'),6(1),7(2),7(3),8(4),8(5),8(6)] THIS UNIT IS UNUSUAL BECAUSE IT WAS INSTALLED FROM THE ENTRY DRIFT INTO WHAT WOULD BECOME THE PILLAR. WHEN THE PILLAR WAS EXCAVATED, ABOUT 220 DAYS AFTER THE UNIT WAS ACTIVATED, THE GAGE 1' ANCHOR WHICH WAS APPROXIMATELY AT 180 DEGREES AND AT 11 METERS RADIUS (MIDROOM LOCATION - IN THE CARTOON THIS ANCHOR IS AT AN INITIAL DEPTH OF 16.5 M FROM THE COLLAR) WAS MINED OUT AND THE RECORD WAS TERMINATED. THE SAME INSTRUMENT CHANNEL WAS REACTIVATED ABOUT 48 DAYS LATER AS GAGE 1 BY INSTALLING A NEW ANCHOR AT THE PILLAR SURFACE WHICH WAS APPROXIMATELY AT 180 DEGREES AND 5.5 METERS RADIUS (IN THE CARTOON THIS ANCHOR IS SHOWN AT A DEPTH OF 11.0 M FROM THE COLLAR). THE RANKING OF 6 FOR GAGE 1 IS A CONSEQUENCE OF THE NEED TO ADJUST THE ORIGINAL DISPLACEMENT ACCORDING TO OTHER INFORMATION. THE ACTUAL DATA QUALITY, EXCLUSIVE OF THE ADJUSTMENT OF GAGE 1, IS GENERALLY EXCELLENT; HOWEVER, GAGES 1, 2 AND 3 HAVE EXTENSIVE DELETIONS AT LATE TIMES AS A RESULT OF POSSIBLE WIRE CLAMPING DUE TO HOLE CLOSURE, WHICH EVENTUALLY RECOVERED NATURALLY OR BY MAINTENANCE ACTIONS. GAGE 1 DATA WERE DELETED AFTER DAY 633, GAGE 2 DATA WERE DELETED BETWEEN DAY 633 AND 664 AND ALSO BETWEEN 800 AND 900, AND GAGE 3 DATA WERE DELETED BETWEEN DAY 790 AND 995. [COMPRESSION = 3.77:1] (DEM)

IT MUST BE NOTED THAT THE DISPLACEMENT POSITION OF GAGE 1 IS STILL APPROXIMATE BECAUSE ENOUGH ANALYSIS OF OTHER DATA HAS NOT BEEN DONE TO PERMIT GOOD EXTRAPOLATIONS TO BE MADE TO LOCATE THE DISPLACEMENT ACCURATELY. DATA OF GAGE 1 SHOULD BE USED WITH CAUTION. (DEM)

***** H_317 Location *****

Principal Station 090
Station 89.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_317-1	EXT	T REM	H	5.56	-5.42	89.81	90.06	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-2	EXT	T REM	H	5.56	-4.02	89.81	90.09	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-3	EXT	T REM	H	5.56	-2.67	89.81	90.20	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-4	EXT	T REM	H	5.56	0.07	89.81	80.34	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-5	EXT	T REM	H	5.56	2.82	89.81	89.69	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	
H_317-6	EXT	T REM	H	5.56	4.21	89.81	89.75	0.57	0.57	0.65	0.65	SERATA	06/25/84	37-6465#01	

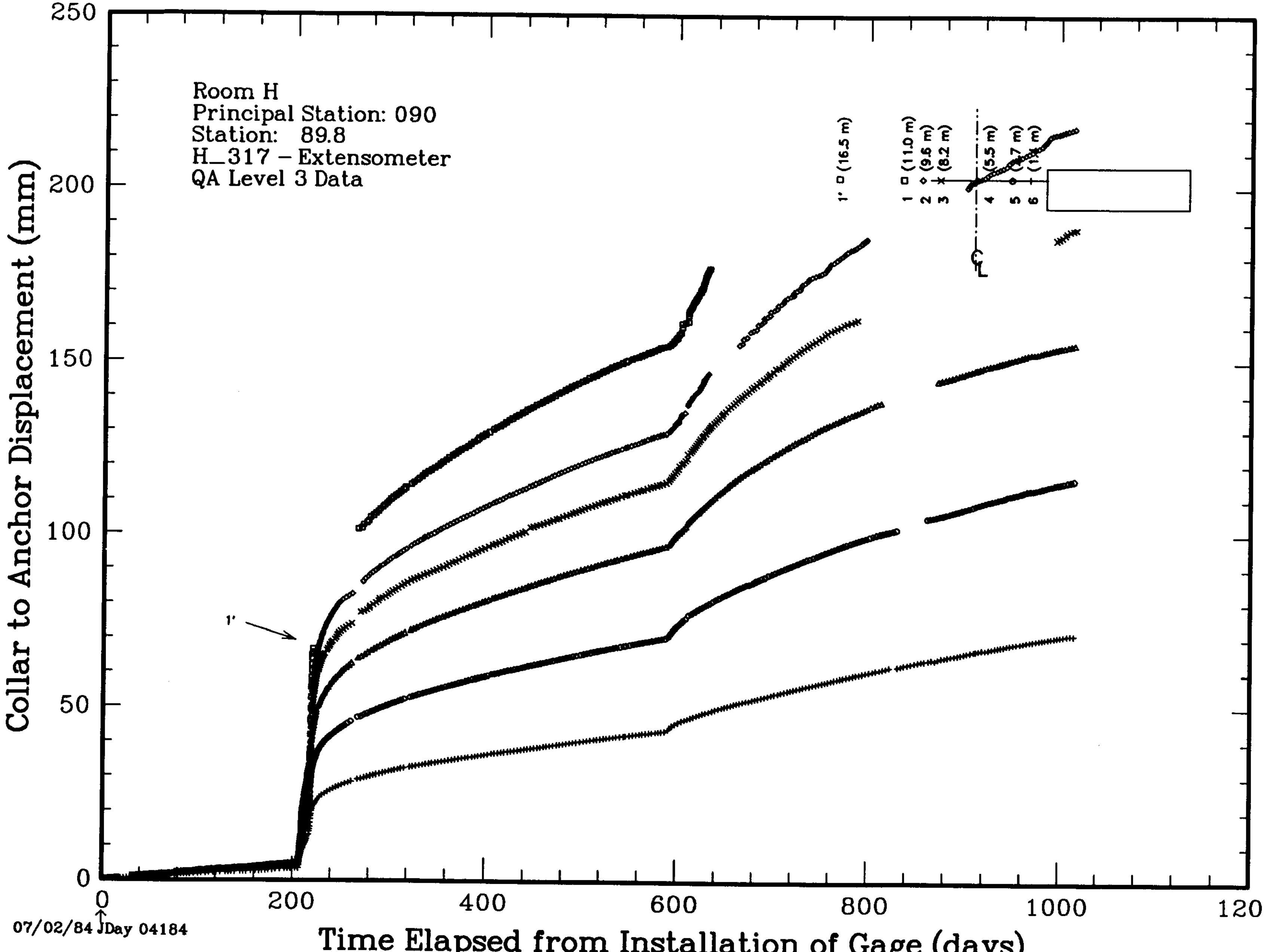

Figure 5.3.1q. Extensometer Gages, H 317

Table 5.3.1r. Extensometer Gages, H 318

Gage: H_318

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***** H_318 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] OUTSTANDING DATA QUALITY FOR THE ENTIRE UNIT. [COMPRESSION = 4.66:1] (DEM)

***** H_318 Location *****

Principal Station 135
Station 134.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_318-1	EXT	P REM	D	5.70	0.20	134.93	135.31	1.37	6.84	1.48	6.94	SERATA	03/12/85	37-6465#06	
H_318-2	EXT	P REM	D	5.70	2.64	134.93	134.93	1.37	4.41	1.48	4.52	SERATA	03/12/85	37-6465#06	
H_318-3	EXT	P REM	D	5.70	3.86	134.93	134.95	1.37	3.19	1.48	3.30	SERATA	03/12/85	37-6465#06	
H_318-4	EXT	P REM	D	5.70	4.79	134.93	134.94	1.37	2.28	1.48	2.39	SERATA	03/12/85	37-6465#06	

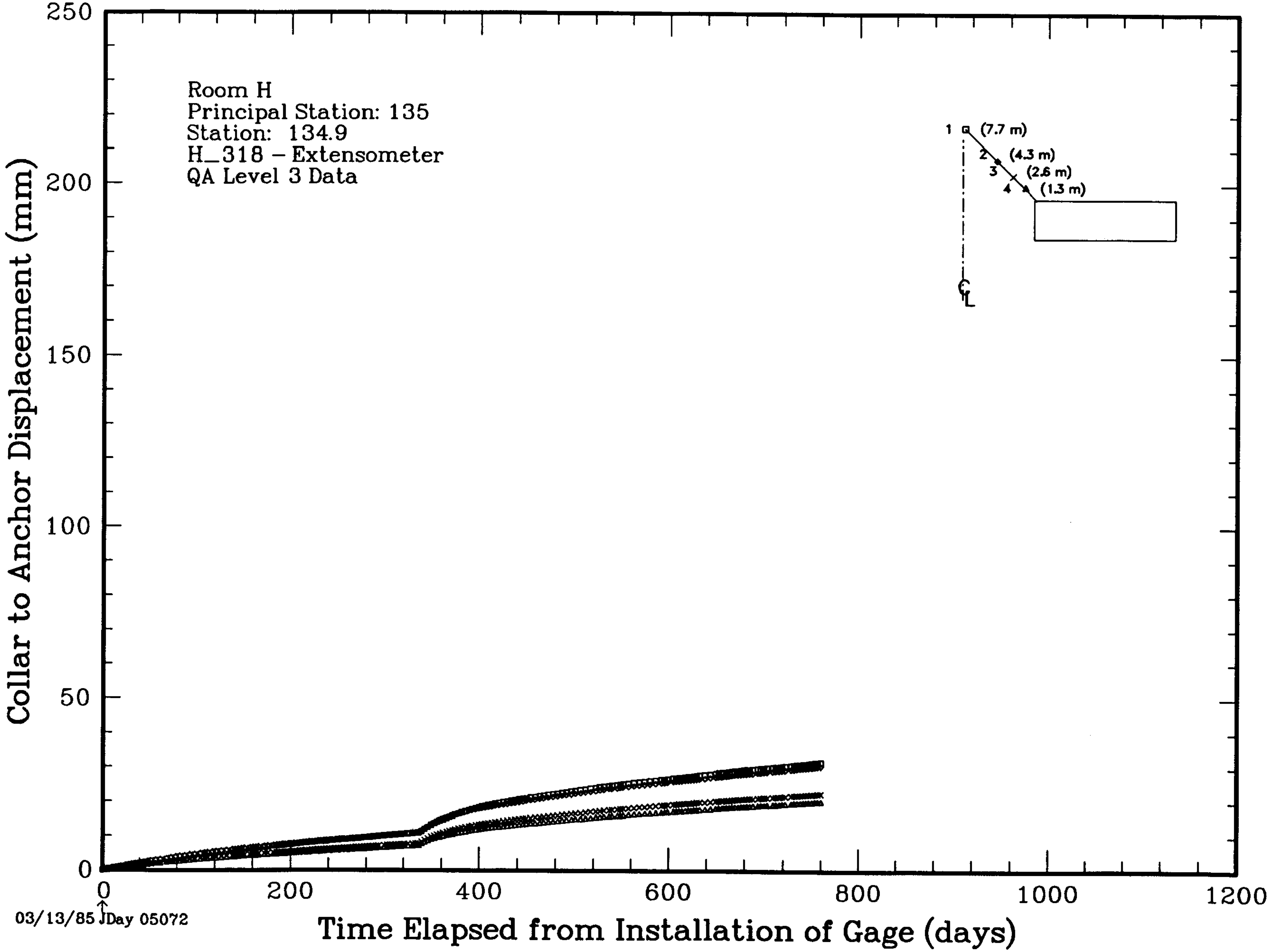

Figure 5.3.1r. Extensometer Gages, H 318

Table 5.3.1s. Extensometer Gages, H 319

Gage: H_319

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***** H_319 PI Comments *****

08/16/87 DLH [RANK = 10(1),10(2),10(3),10(4)] THE DATA OF THE UNIT ARE ALL OUTSTANDING. [COMPRESSION = 15.11:1] (DEM)

***** H_319 Location *****

Principal Station 135
Station 134.9

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_319-1	EXT	P REM	D	5.73	0.23	134.90	130.44	-1.34	-6.81	-1.23	-6.70	SERATA	03/12/85	37-6465#06	
H_319-2	EXT	P REM	D	5.73	2.68	134.90	134.70	-1.34	-4.37	-1.23	-4.27	SERATA	03/12/85	37-6465#06	
H_319-3	EXT	P REM	D	5.73	3.90	134.90	134.80	-1.34	-3.16	-1.23	-3.06	SERATA	03/12/85	37-6465#06	
H_319-4	EXT	P REM	D	5.73	4.81	134.90	134.86	-1.34	-2.25	-1.23	-2.15	SERATA	03/12/85	37-6465#06	

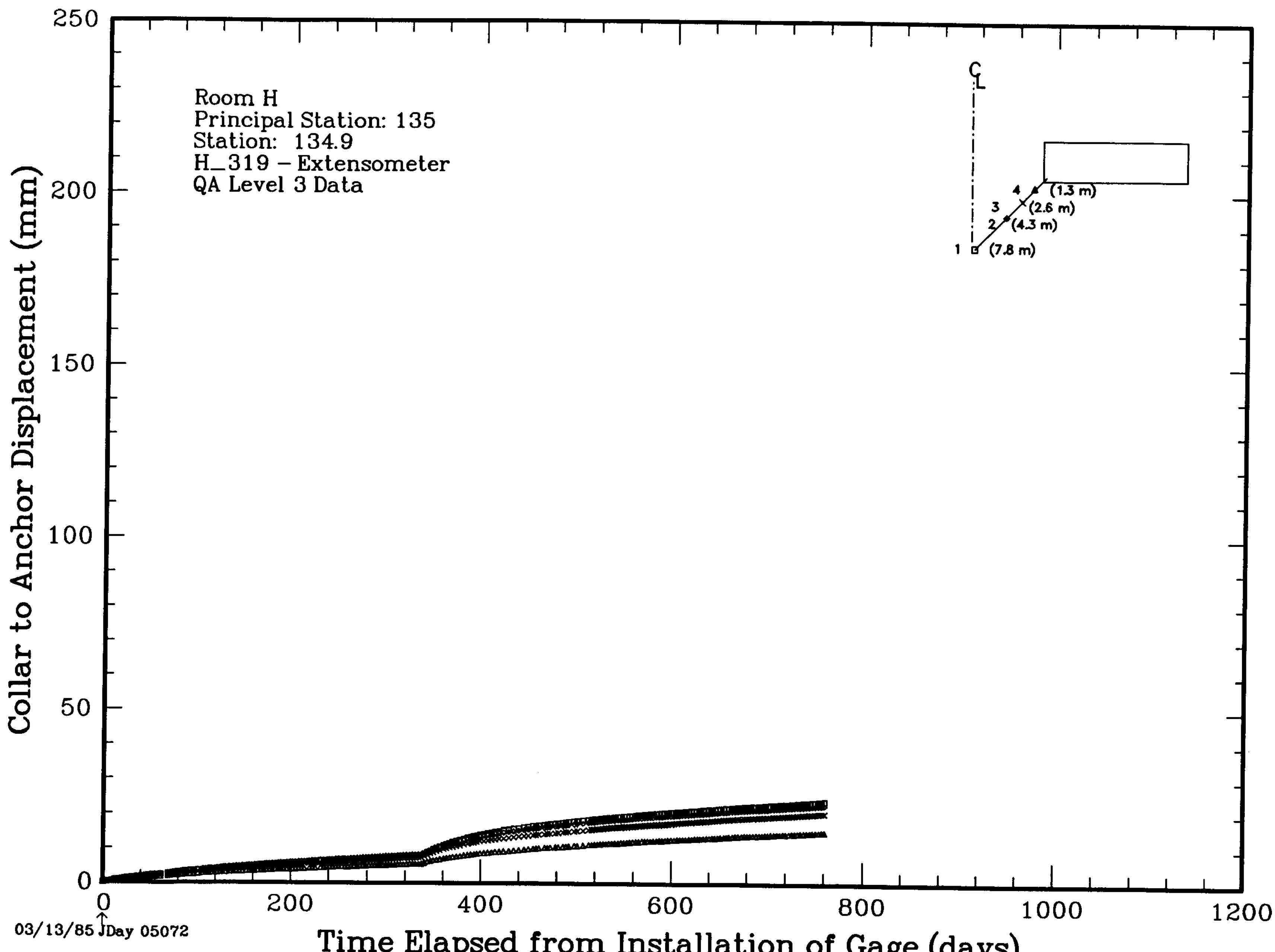

Figure 5.3.1s. Extensometer Gages, H 319

Table 5.3.1t. Extensometer Gages, H 320

Gage: H_320

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***** H_320 PI Comments *****

08/16/87 DEM:DLH [RANK = 5(1),8(2),7(3),8(4),7(5)] GAGE 1 DATA HAD MANY AREAS OF SCATTER AND HYSTERESIS WHICH WERE CORRECTED; AS A CONSEQUENCE THE EXACT DISPLACEMENT LEVEL IS UNCERTAIN. THE REMAINING GAGES ALL HAD HYSTERESIS EFFECTS WHICH WERE CORRECTED, WITH GAGES 3 AND 5 SOMEWHAT MORE THAN GAGES 2 AND 4. IT MUST BE NOTED THAT THE TOTAL DISPLACEMENTS FOR THESE DIAGONAL OUTWARD GAGES IS SIGNIFICANTLY LESS THAN FOR ANY OTHER EXTENSOMETER. [COMPRESSION = 14.18:1] (DEM)

***** H_320 Location *****

Principal Station 135
Station 134.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_320-1	EXT	P REM	D	16.22	26.99	134.95	134.97	1.32	12.09	1.42	12.20	SERATA	03/14/85	37-6465#04	
H_320-2	EXT	P REM	D	16.22	22.68	134.95	134.97	1.32	7.78	1.42	7.89	SERATA	03/14/85	37-6465#04	
H_320-3	EXT	P REM	D	16.22	19.67	134.95	134.96	1.32	4.76	1.42	4.86	SERATA	03/14/85	37-6465#04	
H_320-4	EXT	P REM	D	16.22	17.51	134.95	134.96	1.32	2.61	1.42	2.71	SERATA	03/14/85	37-6465#04	
H_320-5	EXT	P REM	D	16.22	16.86	134.95	134.95	1.32	1.96	1.42	2.07	SERATA	03/14/85	37-6465#04	

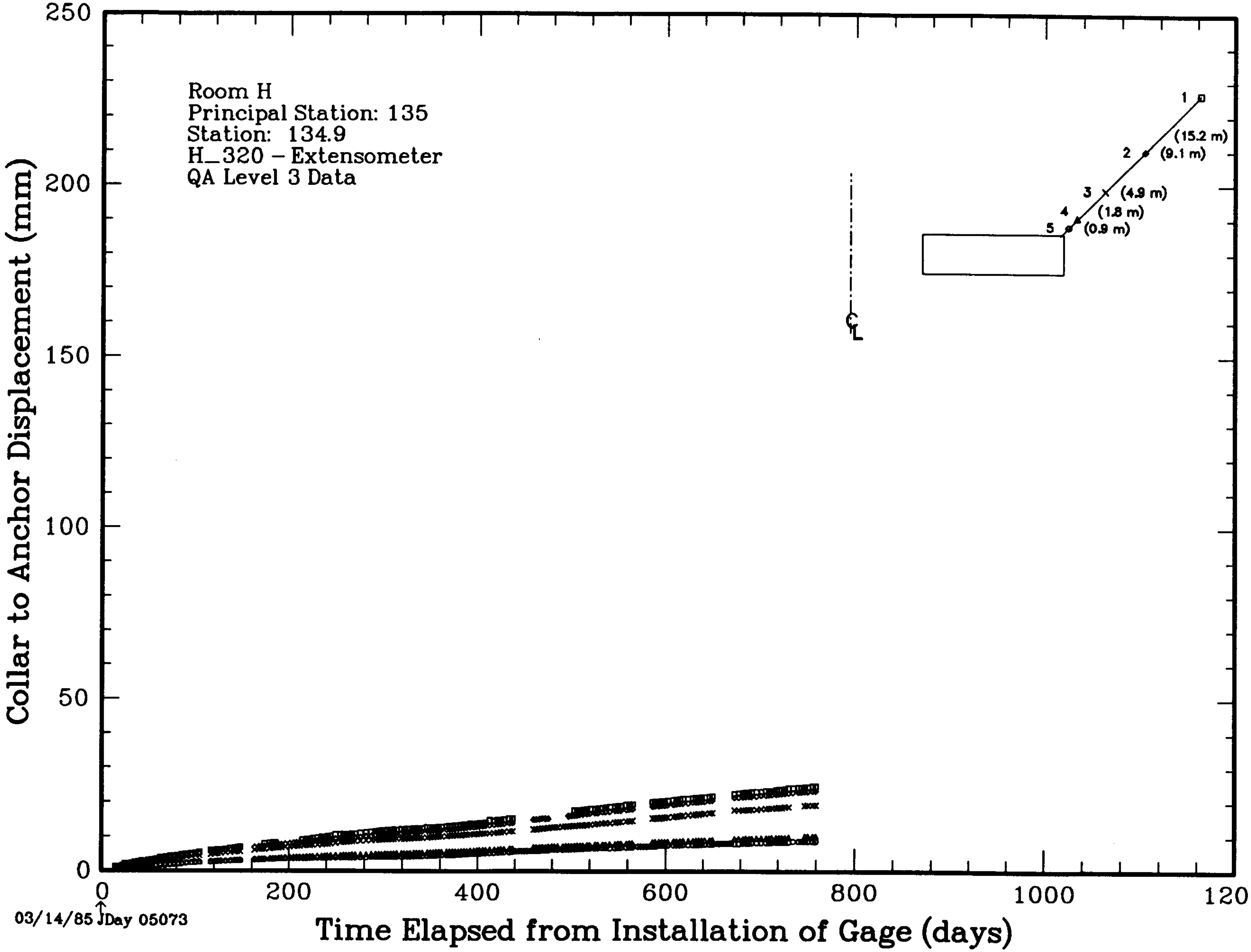

Figure 5.3.1t. Extensometer Gages, H 320

Table 5.3.1u. Extensometer Gages, H 321

Gage: H_321

****

***** H_321 PI Comments *****

08/16/87 DEM:DLH [RANK = 6(1),7(2),8(3),9(4),9(5)] GAGE 1 REQUIRED MANY CORRECTIONS FOR HYSTERESIS AND SHIFTS. GAGE 2 HAD SIMILAR, BUT FEWER, CORRECTIONS COMPARED TO GAGE 1. IN GENERAL THE HYSTERESIS AND SHIFTS FOR GAGES 3, 4, AND 5 WERE FEW AND RATHER SIMPLE. [COMPRESSION 16.19:1] (DEM)

***** H_321 Location *****

Principal Station 135
Station 134.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_321-1	EXT	P REM	D	16.16	26.94	134.94	134.96	-1.36	-12.13	-1.26	-12.03	SERATA	03/13/85	37-6465#04	
H_321-2	EXT	P REM	D	16.16	22.63	134.94	134.95	-1.36	-7.82	-1.26	-7.72	SERATA	03/13/85	37-6465#04	
H_321-3	EXT	P REM	D	16.16	19.61	134.94	134.95	-1.36	-4.80	-1.26	-4.70	SERATA	03/13/85	37-6465#04	
H_321-4	EXT	P REM	D	16.16	17.46	134.94	134.94	-1.36	-2.65	-1.26	-2.55	SERATA	03/13/85	37-6465#04	
H_321-5	EXT	P REM	D	16.16	16.81	134.94	134.94	-1.36	-2.00	-1.26	-1.90	SERATA	03/13/85	37-6465#04	

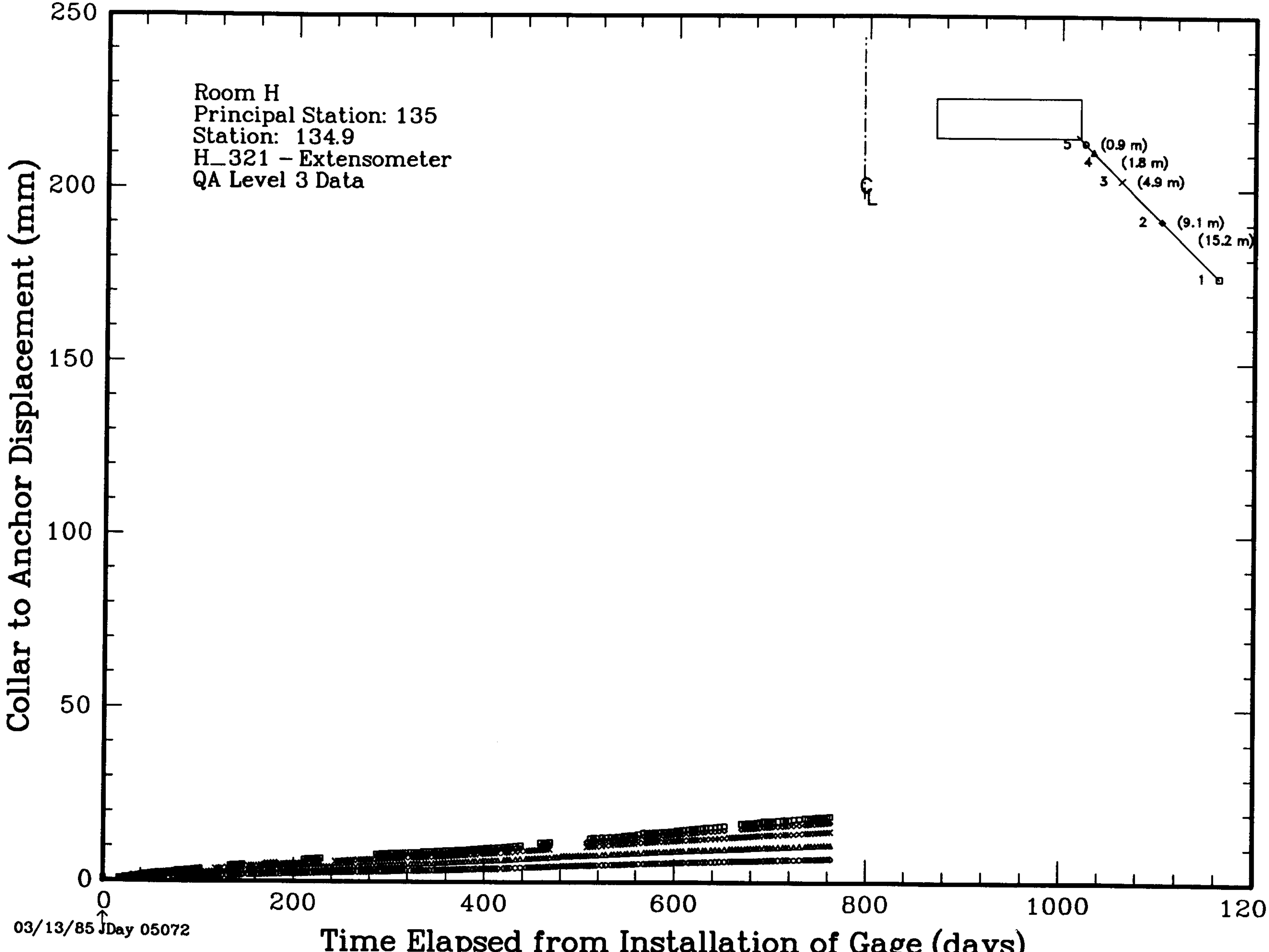

Figure 5.3.1u. Extensometer Gages, H 321

Table 5.3.1v. Extensometer Gages, H 326

Gage: H_326

****

***** H_326 PI Comments *****

08/18/87 DLH [RANK = 9(1),7(2),7(3),8(4)] BOTH GAGES 2 AND 3 HAD SALT BUILDUP WHICH CAUSED ERRORS IN THE DATA; HOWEVER, THESE PROBLEMS WERE CORRECTED BY REINSTALLATION OF THE GAGE. GAGE 3 ALSO HAD AN ELECTRICAL NOISE PROBLEM, WHICH RESULTED IN LOSS OF DATA. GAGE 1 DATA WERE EXCEPTIONAL, WITH ONLY THE REINSTALLATION CORRECTION. GAGE 4 RECEIVED A LOWER RANKING DUE TO SOME HYSTERESIS EFFECTS. [COMPRESSION = 4.66:1] (DEM)

***** H_326 Location *****

Principal Station 315
Station 315.1

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_326-1	EXT	P REM	D	5.73	0.25	315.07	316.75	1.29	6.77	1.20	6.69	SERATA	03/11/85	37-6465#06	
H_326-2	EXT	P REM	D	5.73	2.68	315.07	315.16	1.29	4.34	1.20	4.26	SERATA	03/11/85	37-6465#06	
H_326-3	EXT	P REM	D	5.73	3.90	315.07	315.11	1.29	3.12	1.20	3.03	SERATA	03/11/85	37-6465#06	
H_326-4	EXT	P REM	D	5.73	4.82	315.07	315.09	1.29	2.20	1.20	2.12	SERATA	03/11/85	37-6465#06	

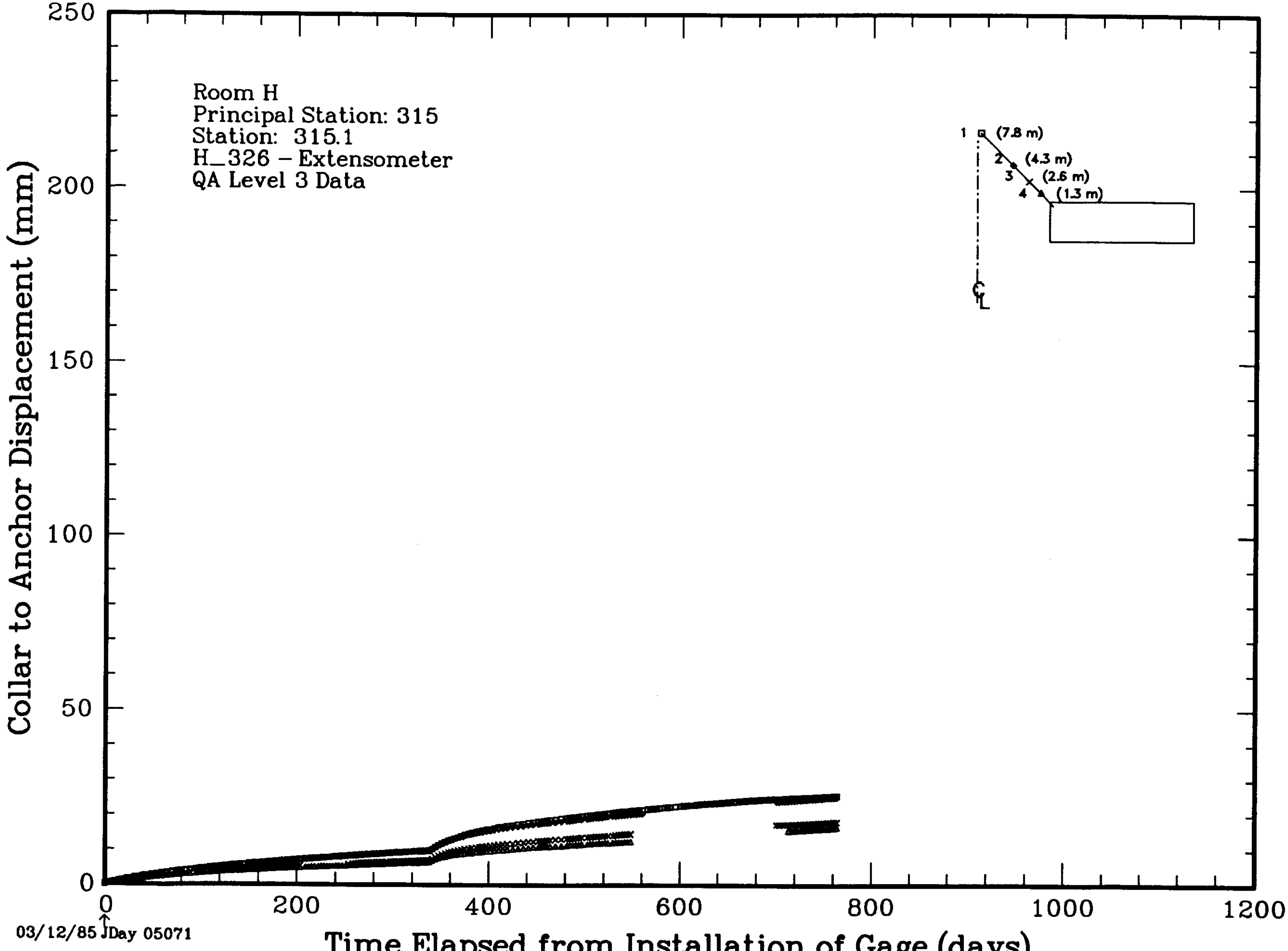

Figure 5.3.1v. Extensometer Gages, H 326

Table 5.3.1w. Extensometer Gages, H 327

Gage: H_327

****

***** H_327 PI Comments *****

08/16/87 DLH [RANK = 10(1),10(2),10(3),9(4)] THESE DATA ARE ALL OUTSTANDING, EXCEPT FOR GAGE 4 DATA WHICH REQUIRED A SINGLE SMALL SHIFT AT LEVEL 3. [COMPRESSION 15.74:1] (DEM)

***** H_327 Location *****

Principal Station 315
Station 315.2

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_327-1	EXT	P REM	D	5.74	0.25	315.16	318.68	-1.45	-6.94	-1.53	-7.02	SERATA	03/11/85	37-6465#06	
H_327-2	EXT	P REM	D	5.74	2.69	315.16	315.34	-1.45	-4.50	-1.53	-4.58	SERATA	03/11/85	37-6465#06	
H_327-3	EXT	P REM	D	5.74	3.91	315.16	315.24	-1.45	-3.28	-1.53	-3.36	SERATA	03/11/85	37-6465#06	
H_327-4	EXT	P REM	D	5.74	4.82	315.16	315.19	-1.45	-2.37	-1.53	-2.45	SERATA	03/11/85	37-6465#06	

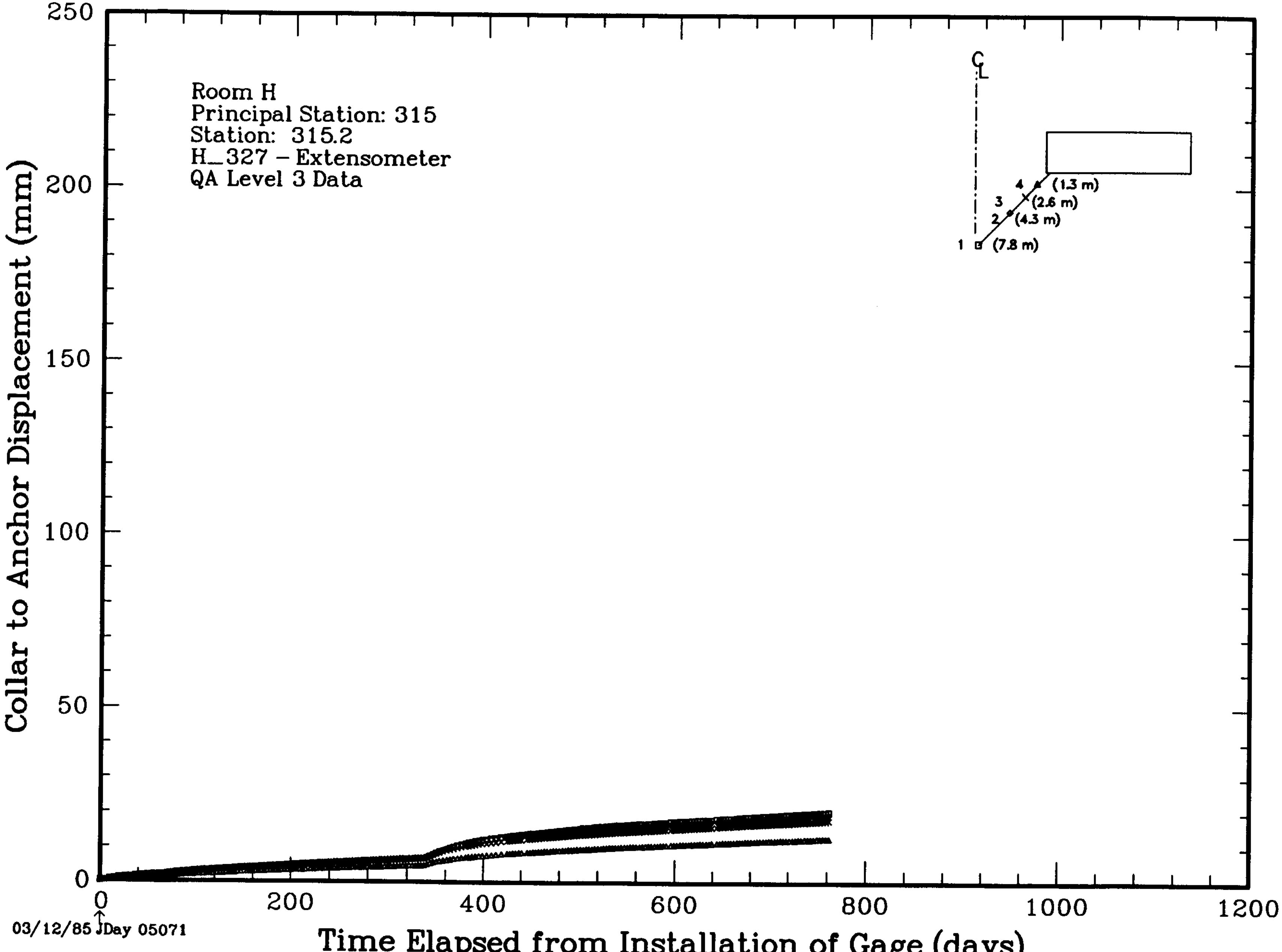

Figure 5.3.1w. Extensometer Gages, H 327

Table 5.3.1x. Extensometer Gages, H 328

Gage: H_328

***** H_328 PI Comments *****

08/16/87 DLH [RANK = 7(1),3(2),8(3),8(4),8(5)] THE DATA OF GAGES 1 AND 2 IN TERMS OF QUALITY ARE EQUAL AT A RANKING OF 7; HOWEVER, IT APPEARS THAT GAGE 2 IS GIVING IDENTICAL READINGS TO GAGE 1 AND THE TWO ARE LINKED. THIS HAS RESULTED IN THE LOW RANKING OF GAGE 2. GAGES 3, 4, AND 5 ALL HAVE SEVERAL HYSTERESIS EFFECTS CORRECTED DURING REDUCTION. [COMPRESSION = 16.13:1] (DEM)

***** H_328 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_328-1	EXT	P REM	D	16.25	27.03	314.97	314.99	1.36	12.14	1.28	12.06	SERATA	03/11/85	37-6465#04	
H_328-2	EXT	P REM	D	16.25	22.72	314.97	314.98	1.36	7.83	1.28	7.74	SERATA	03/11/85	37-6465#04	
H_328-3	EXT	P REM	D	16.25	19.70	314.97	314.98	1.36	4.81	1.28	4.73	SERATA	03/11/85	37-6465#04	
H_328-4	EXT	P REM	D	16.25	17.55	314.97	314.98	1.36	2.65	1.28	2.57	SERATA	03/11/85	37-6465#04	
H_328-5	EXT	P REM	D	16.25	16.90	314.97	314.98	1.36	2.01	1.28	1.93	SERATA	03/11/85	37-6465#04	

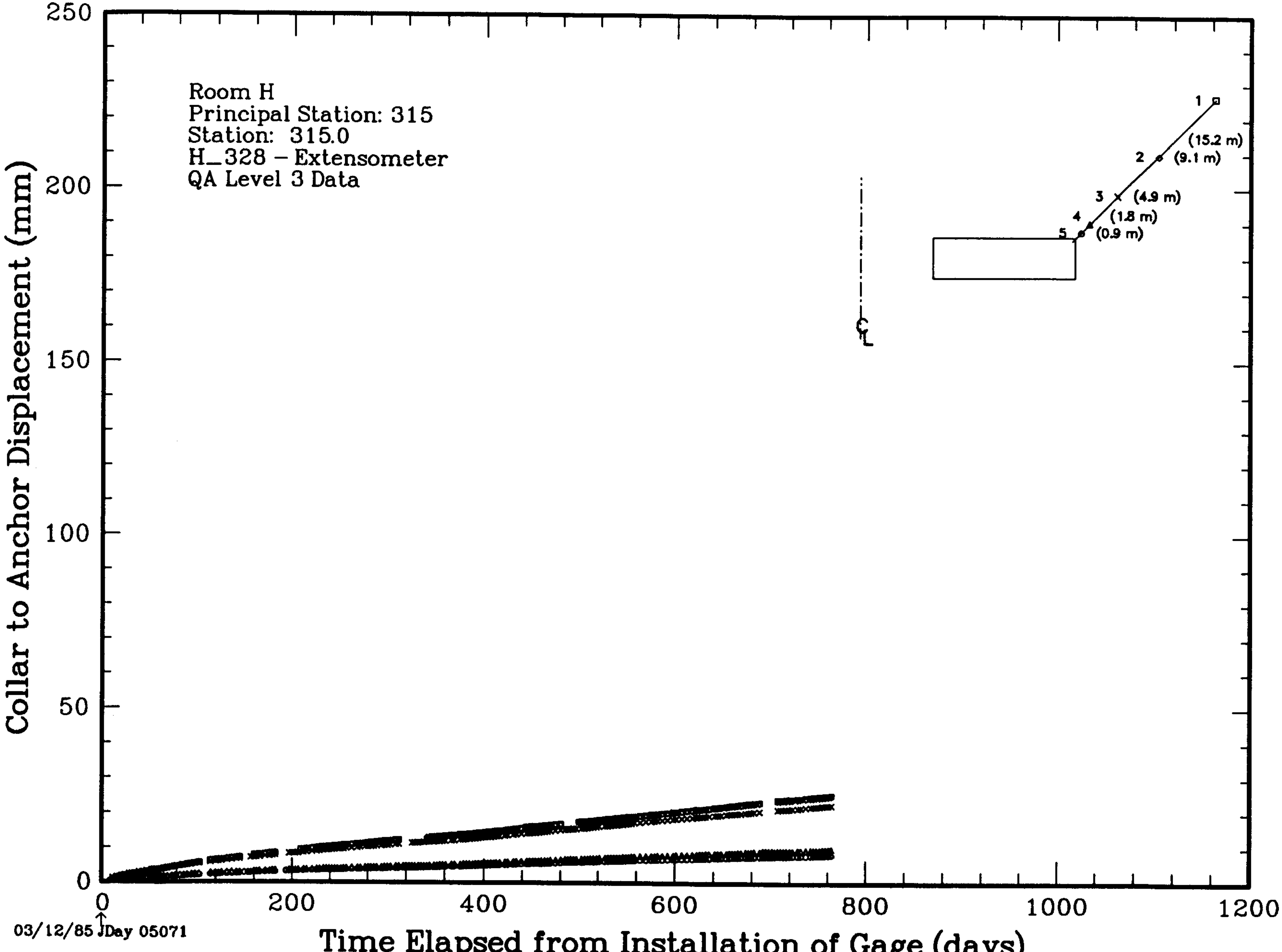

Figure 5.3.1x. Extensometer Gages, H 328

Table 5.3.1y. Extensometer Gages, H 329

Gage: H_329

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***** H_329 PI Comments *****

08/16/87/ DLH [RANK = 2(1),2(2),6(3),7(4),7(5)] GAGE 1 AND 2 APPEAR TO BE LINKED; HOWEVER, IT IS DIFFICULT TO ASSIGN MUCH VALUE TO THE DISPLACEMENTS OF EITHER GAGE BECAUSE OF EXCESSIVE DELETION OF EARLY DATA DUE TO SCATTER AND HYSTERESIS. THE RELATIVE POSITIONS OF THE LATER GAGE 1 AND 2 DATA ARE OBTAINED FROM UNIT H_321. GAGE 3 HAS HAD CONSIDERABLE DATA DELETED BECAUSE OF HYSTERESIS. GAGES 4 AND 5, WHILE REQUIRING SOME CORRECTIONS AND DELETIONS FOR HYSTERESIS AND MINOR SHIFTS, ARE GENERALLY EXCELLENT. [COMPRESSION = 10.69:1] (DEM)

***** H_329 Location *****

Principal Station 315
Station 315.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_329-1	EXT	P REM	D	16.19	26.96	315.03	315.01	-1.39	-12.16	-1.47	-12.24	SERATA	03/13/85	37-6465#04	
H_329-2	EXT	P REM	D	16.19	22.65	315.03	315.02	-1.39	-7.85	-1.47	-7.93	SERATA	03/13/85	37-6465#04	
H_329-3	EXT	P REM	D	16.19	19.64	315.03	315.02	-1.39	-4.83	-1.47	-4.91	SERATA	03/13/85	37-6465#04	
H_329-4	EXT	P REM	D	16.19	17.48	315.03	315.02	-1.39	-2.68	-1.47	-2.76	SERATA	03/13/85	37-6465#04	
H_329-5	EXT	P REM	D	16.19	16.83	315.03	315.02	-1.39	-2.03	-1.47	-2.11	SERATA	03/13/85	37-6465#04	

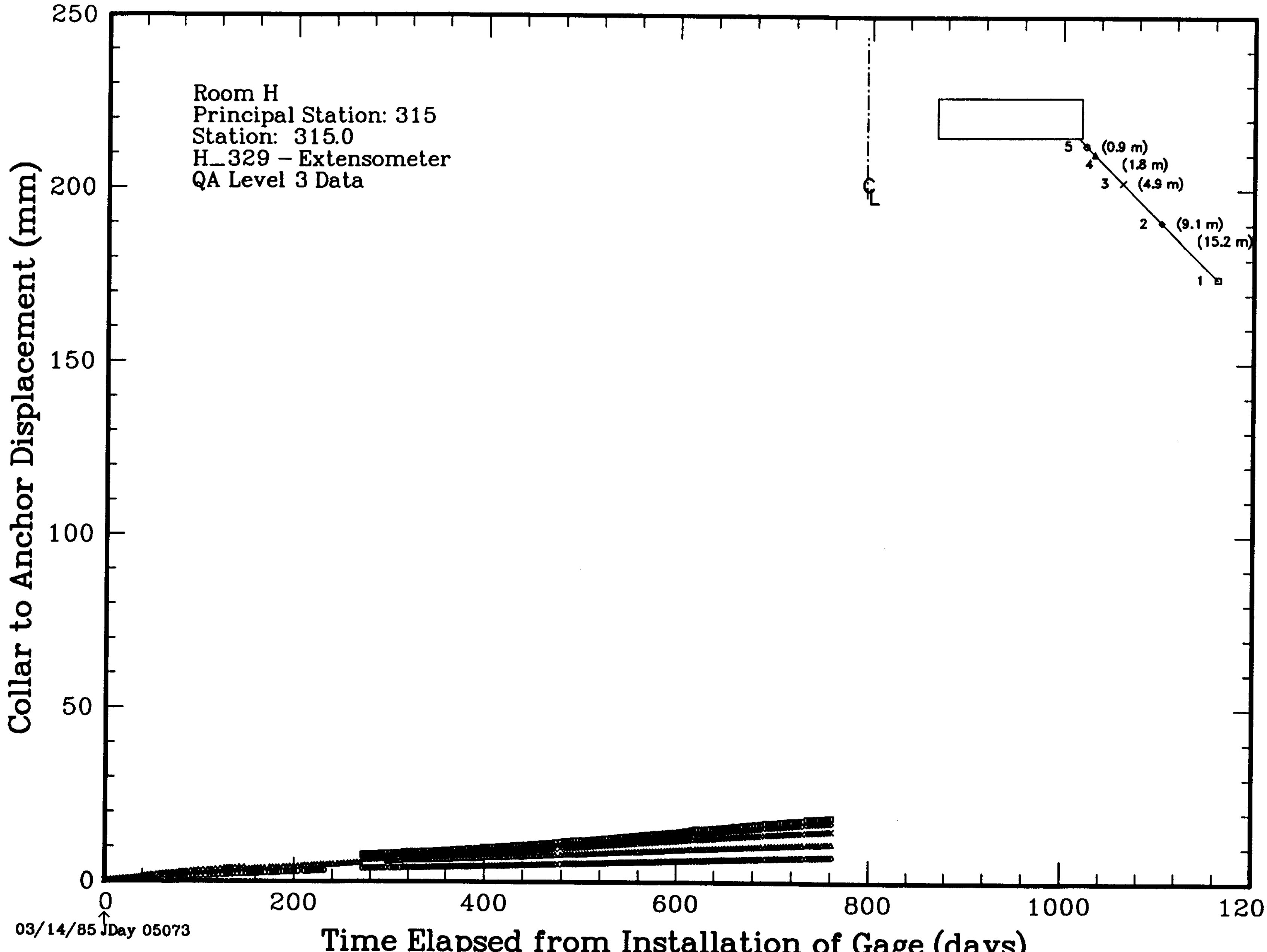

Figure 5.3.1y. Extensometer Gages, H 329

5.4 Stress Meter Measurements

A guide to the location of all temporary and permanent BuMines and SGS stress meter units (gages) installed in Room H is given in Table 5.4.1. The table shows schematically the relative unit positions at the principal stations of the room. In general, the gage numbers of logical collections of gages are in sequence. BuMines units H 501 through H 516 (with some numbers deleted because of design changes) are vertical units in the roof and floor. BuMines units H 519 through H 536 (again some numbers deleted) are horizontal units in the pillar and rib. The pillar is instrumented with diagonal BuMines units H 537, H 538, H 544, and H 543. Early stress meters of the SGS type were placed in the pillar material before excavation of the room. These units, H 549 through H 551, are horizontal emplacements at about 1/3 the height between floor and roof.

For the BuMines stress meters, Tables 5.4.1a-t give comments, and Figures 5.4.1a-t show the data for these gages. For the SGS stress meters, Tables 5.4.2a-c give comments, and Figures 5.4.2a-c show the data for these gages.

Historically, the measurement of stress fields around underground openings has been difficult and often controversial. This situation is compounded in salt because of the time-dependent creep processes that occur around <u>any</u> underground, stressed opening. The scale of the opening does not alter this behavior, and the small gage emplacement borehole experiences the same effects as the large drift or room. As a consequence, any stress meter emplaced in salt will give a response reflecting both the time-dependent conditions around the emplacement hole and the time-dependent conditions around the room. The nature of these conditions is such that, in the absence of three-dimensional (3-D) effects on the gage, a stress meter will come into equilibrium in time with the stress field around the room. To some extent, then, this equilibrium is what we are looking for in the stress meter data. And, in lieu of a complete analysis, we are looking for similarities and trends in the data, depending on gage location and elapsed time.

Remember that the BuMines gages predominate in this test. A BuMines gage unit consists of an array of one cylindrical pressure cell (CPC) and two orthogonal borehole pressure cells (BPCs). The CPC senses the mean stress (pressure) in the plane normal to the axis of the cylindrical cell. The BPCs are small, flat jacks or pressure cells sensing the pressure normal to the flat face of the jack. BuMines "stress meters" actually measure cell pressure.

Three units of the strain-gaged stress meter (SGS) consisting of three SGS gages in a 120°, 90°, and 60° rosette array were in the pillar. SGS gages actually measure a strain in an elastic beam produced by the force on the gage platen. The force applied is converted to stress (pressure) through a calibration.

The measured response of symmetrically emplaced BuMines gage arrays gives clearly similar results. This can be seen, for example, in the arrays of units H 501 and H 513 (Figures 5.4.1a and 5.4.1e) and of units H 502 and H 514 (Figures 5.4.1b and 5.4.1f), which are units in the salt above the roof of the room. Any BuMines gage has a characteristic response curve. The initial pressurization of the estimated lithostatic stress magnitude of 14.8 MPa (2150 psi) is rapidly relaxed to a much lower value. Then the pressure change reverses and gradually increases with a

Table 5.4.1. Stress Meter Units (Gages) Location Guide

Station	Direction		Relative Location: pillar	center	rib
H ST180	Vertical	roof		H 501	
	Vertical	roof		H 502	
	Diagonal	52.5	H 537		
	Diagonal				
	Horizontal	mid	H 519,H 520		H 524,H 523
	Diagonal				
	Diagonal	52.5	H 543		
	Vertical	floor		H 505	
	Vertical	floor		H 504	
H ST000	Vertical	roof		H 513	
	Vertical	roof		H 514	
	Diagonal				
	Diagonal	30.0	H 538		
	Horizontal	mid	H 532,H 533		H 536,H 535
	Diagonal	30.0	H 544		
	Diagonal				
	Vertical	floor		H 517	
	Vertical	floor		H 516	
H ST090	Vertical	roof			
	Diagonal				
	Diagonal				
	Horizontal		H 549,H 550,H 551		
	Diagonal				
	Diagonal				
	Vertical	floor			

diminishing rate apparently approaching asymptotically to an equilibrium pressure value. Because the oil pressure medium expands with increases in temperature, the heat response is pronounced. However, the pressurization is not fundamentally different from any intentional pressurization and it should not affect the eventual approach to equilibrium. The thermal expansion can and must, of course, be incorporated into any analysis of the data. In practice, however, the increase in pressure from thermal expansion can exceed the burst strength of the gage, and this may cause failure in those gages in the pillar where the temperature increase is the greatest. Only one gage, H 533-3, appears to have survived in the heated pillar. The cause of failure is uncertain because some gages show considerable latitude in the time to failure.

As in the case of the BuMines gages, the SGS gages had an initial platen force applied equivalent to the lithostatic pressure of 14.8 MPa (2150 psi). This force quickly relaxed to a much lower value, and then gradually increased as the gage began to interact with the salt. This gradual increase was changed markedly when the mining of the room produced the severe pillar loads. A discussion of the SGS gage response to the mining activity was presented in Section 5.1, and is not repeated here.

In a qualitative sense the gage responses are reasonable; eventually, however, a quantitative analysis of the results is necessary for correct determination of the stress fields around Room H. To perform the detailed analyses, the analyst requires precise location information for these units as given in the individual gage location comments. Although it is apparent from the gage location coordinates, the analyst should be aware that the spatial distribution of a BuMines unit (array) may span up to 1.52 m (5 ft), which can be significant in a stress field with steep gradients. The spatial distribution of a SGS unit (array) is more confined, with a span of only about 0.46 m (1.5 ft).

The analyst needs, also, a detailed orientation of the sensing element of the gage. In Figure 5.4.3, we have defined a local cartesian coordinate system centered at the sensing element. The x and y axes of

Table 5.4.1a. BuMines Stress Meters, H 501

Gage: H_501

****

***** H_501 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] OUTSTANDING RECORD FOR THIS UNIT, WITH
A VERY LONG LIFE. [COMPRESSION = 5.16:1] (DEM)

***** H_501 Location *****

Principal Station 180
Station 176.8

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_501-1	STR	P REM	V	11.09	11.03	176.83	177.43	1.45	9.68	1.49	9.72	ROGERS	03/18/85	58-3374#03	X 0.000Y 0.000Z+1.000
H_501-2	STR	P REM	V	11.09	11.03	176.83	177.36	1.45	8.76	1.49	8.81	ROGERS	03/18/85	58-3374#07	X+0.998Y-0.055Z 0.000
H_501-3	STR	P REM	V	11.09	11.04	176.83	177.32	1.45	8.22	1.49	8.27	ROGERS	03/18/85	58-3374#07	X+0.055Y+0.998Z 0.000

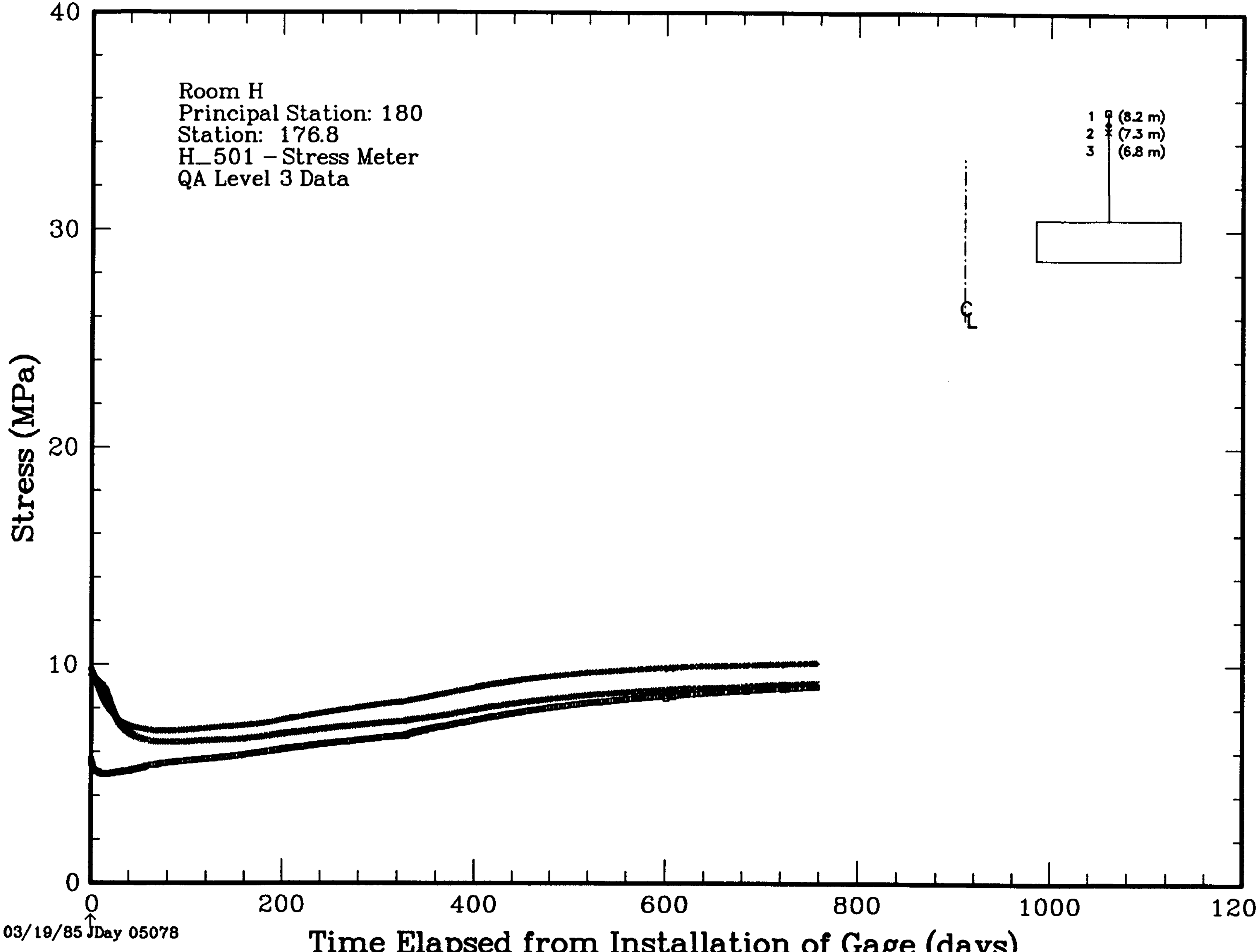

Figure 5.4.1a. BuMines Stress Meters, H 501

Table 5.4.1b. BuMines Stress Meters, H 502

Gage: H_502

****

***** H_502 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] OUTSTANDING DATA QUALITY FOR THE ENTIRE UNIT. [COMPRESSION = 4.66:1] (DEM)

***** H_502 Location *****

Principal Station 180
Station 183.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_502-1	STR	P REM	V	10.94	10.95	182.98	183.04	1.48	5.45	1.52	5.50	ROGERS	03/19/85	58-3374#04	X 0.000Y 0.000Z+1.000
H_502-2	STR	P REM	V	10.94	10.95	182.98	183.02	1.48	4.52	1.52	4.57	ROGERS	03/19/85	58-3374#08	X+0.999Y+0.052Z 0.000
H_502-3	STR	P REM	V	10.94	10.95	182.98	183.02	1.48	3.98	1.52	4.03	ROGERS	03/19/85	58-3374#08	X-0.052Y+0.999Z 0.000

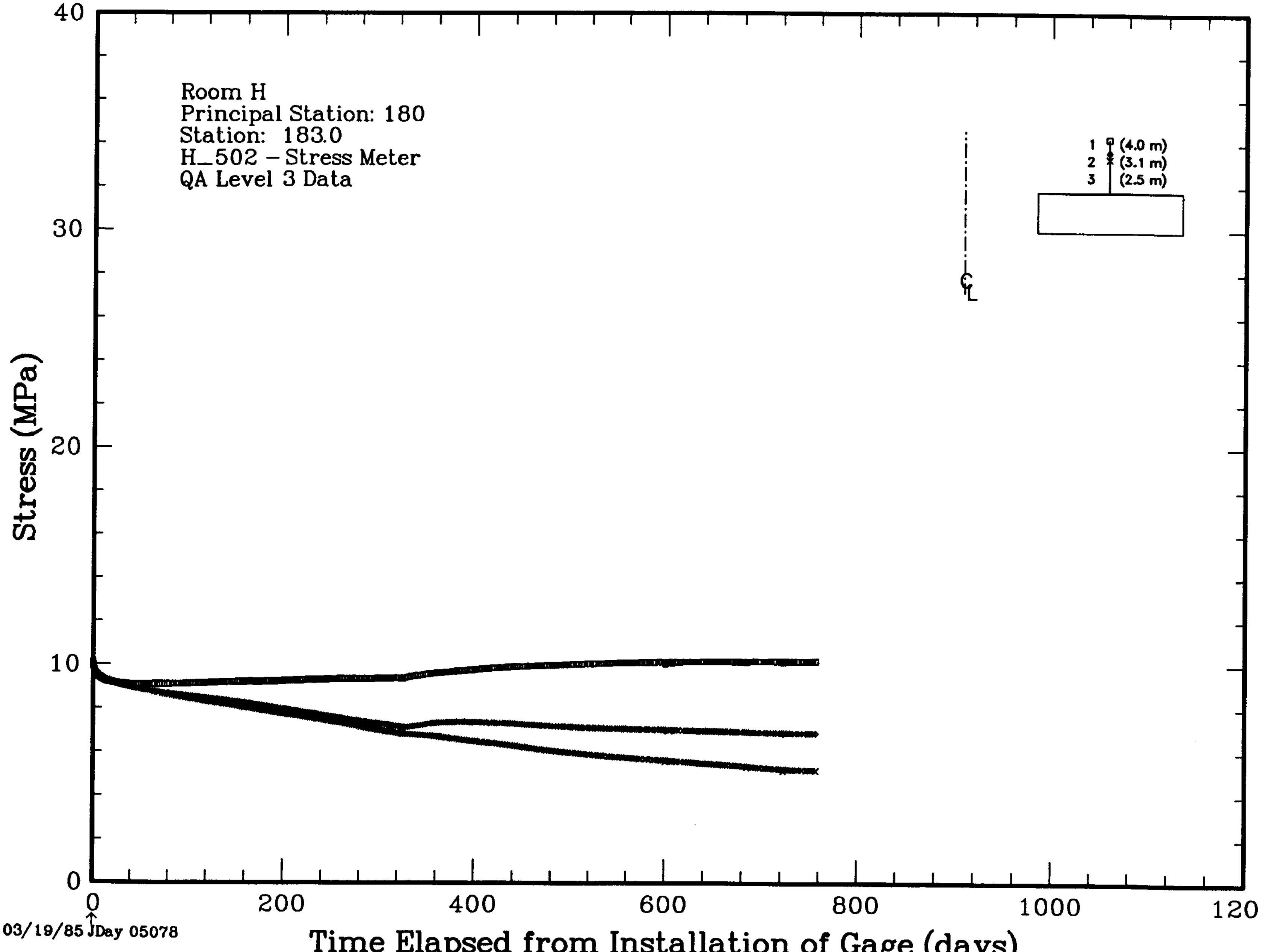

Figure 5.4.1b. BuMines Stress Meters, H 502

Table 5.4.1c. BuMines Stress Meters, H 504

Gage: H_504

****

***** H_504 PI Comments *****

08/18/87 DLH:DEM [RANK = 10(1),10(2),10(3)] OUTSTANDING DATA QUALITY FOR THE ENTIRE UNIT. THE RETROFIT AT DAY 636 OF GAGE 2 TO REPLACE THE TRANSDUCER INVOLVED A DE- AND REPRESSURIZATION. AT THIS TIME IT IS NOT CLEAR WHETHER THE SUBSEQUENT GAGE DATA SHOULD BE SHIFTED OR NOT. NO ACTION WAS TAKEN. IF AT THE NEXT UPDATE IT APPEARS THAT THE REPRESSURIZED GAGE IS COMING TO A NEW EQUILBRIUM VALUE, THE GAGE DATA CAN BE ADJUSTED AT THAT TIME TO BRING THE OLD AND NEW EQUILBRIUM VALUES INTO AGREEMENT. [COMPRESSION = 4.66:1] (DEM)

***** H_504 Location *****

Principal Station 180
Station 176.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_504-1	STR	P REM	V	10.95	10.93	176.93	176.46	-1.44	-9.67	-1.40	-9.63	ROGERS	03/29/85	58-3374#03	X 0.000Y 0.000Z+1.000
H_504-2	STR	P REM	V	10.95	10.93	176.93	176.51	-1.44	-8.76	-1.40	-8.71	ROGERS	03/29/85	58-3374#07	X+0.998Y-0.054Z 0.000
H_504-3	STR	P REM	V	10.95	10.93	176.93	176.54	-1.44	-8.22	-1.40	-8.17	ROGERS	03/29/85	58-3374#07	X+0.054Y+0.998Z 0.000

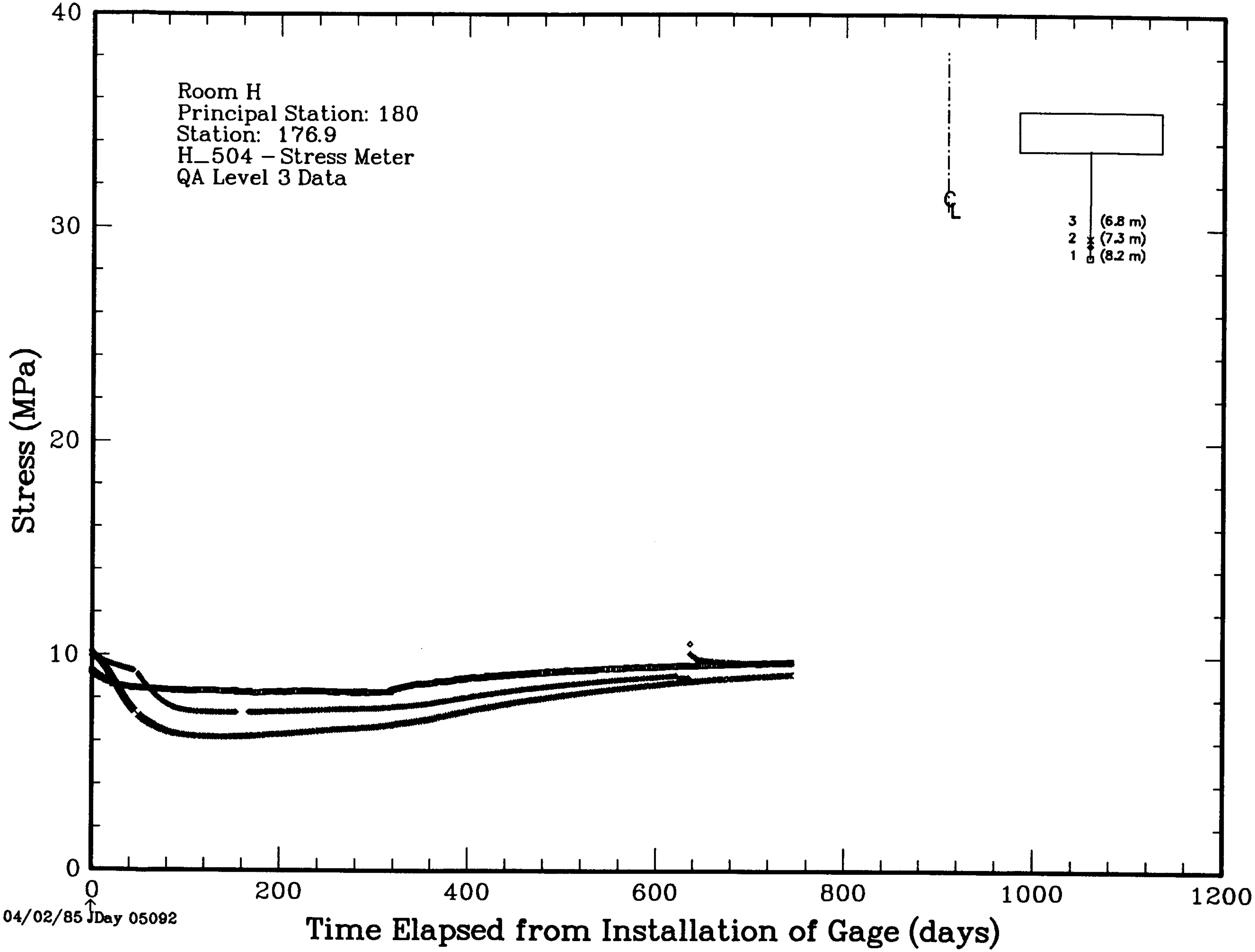

Figure 5.4.1c. BuMines Stress Meters, H 504

Table 5.4.1d. BuMines Stress Meters, H 505

Gage: H_505

****

***** H_505 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] OUTSTANDING DATA QUALITY FOR THE ENTIRE UNIT. [COMPRESSION = 4.66:1] (DEM)

***** H_505 Location *****

Principal Station 180
Station 183.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_505-1	STR	P REM	V	10.95	10.94	183.04	182.80	-1.48	-5.44	-1.43	-5.39	ROGERS	04/01/85	58-3374#04	X 0.000Y 0.000Z+1.000
H_505-2	STR	P REM	V	10.95	10.95	183.04	182.85	-1.48	-4.53	-1.43	-4.48	ROGERS	04/01/85	58-3374#08	X+0.999Y+0.053Z 0.000
H_505-3	STR	P REM	V	10.95	10.95	183.04	182.88	-1.48	-3.99	-1.43	-3.94	ROGERS	04/01/85	58-3374#08	X-0.053Y+0.999Z 0.000

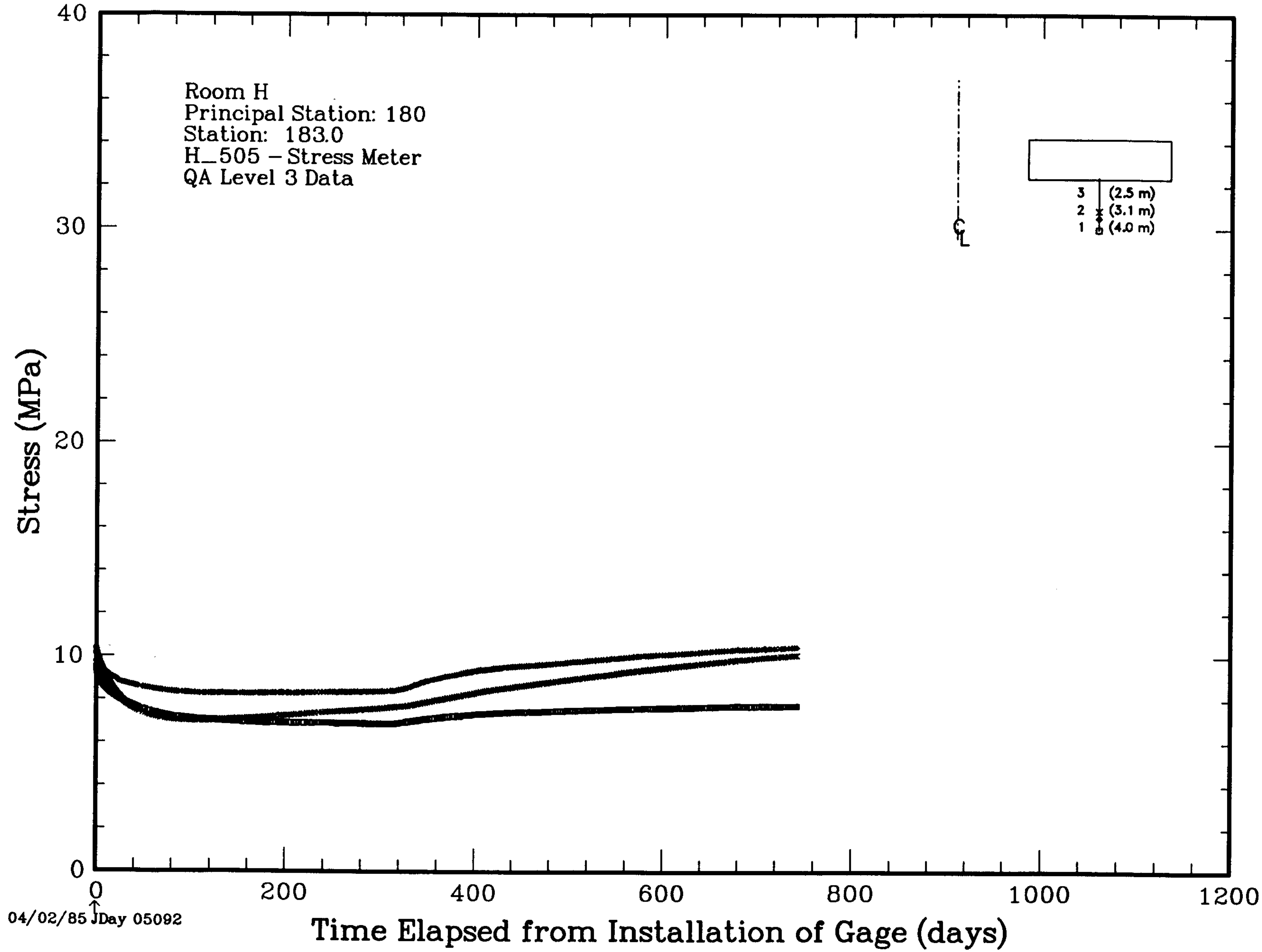

Figure 5.4.1d. BuMines Stress Meters, H 505

Table 5.4.1e. BuMines Stress Meters, H 513

Gage: H_513

****

***** H_513 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] ALL THE DATA ARE OUTSTANDING FOR THE UNIT; HOWEVER, GAGE 2 NOW APPEARS TO HAVE FAILED ON DAY 761. [COMPRESSION = 3.72:1] (DEM)

***** H_513 Location *****

Principal Station 000
Station 356.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_513-1	STR	P REM	V	10.94	10.88	356.86	357.58	1.40	9.63	1.42	9.65	ROGERS	03/13/85	58-3374#03	X 0.000Y 0.000Z+1.000
H_513-2	STR	P REM	V	10.94	10.89	356.86	357.51	1.40	8.71	1.42	8.74	ROGERS	03/13/85	58-3374#07	X+0.998Y-0.055Z 0.000
H_513-3	STR	P REM	V	10.94	10.89	356.86	357.46	1.40	8.17	1.42	8.20	ROGERS	03/13/85	58-3374#07	X+0.055Y+0.998Z 0.000

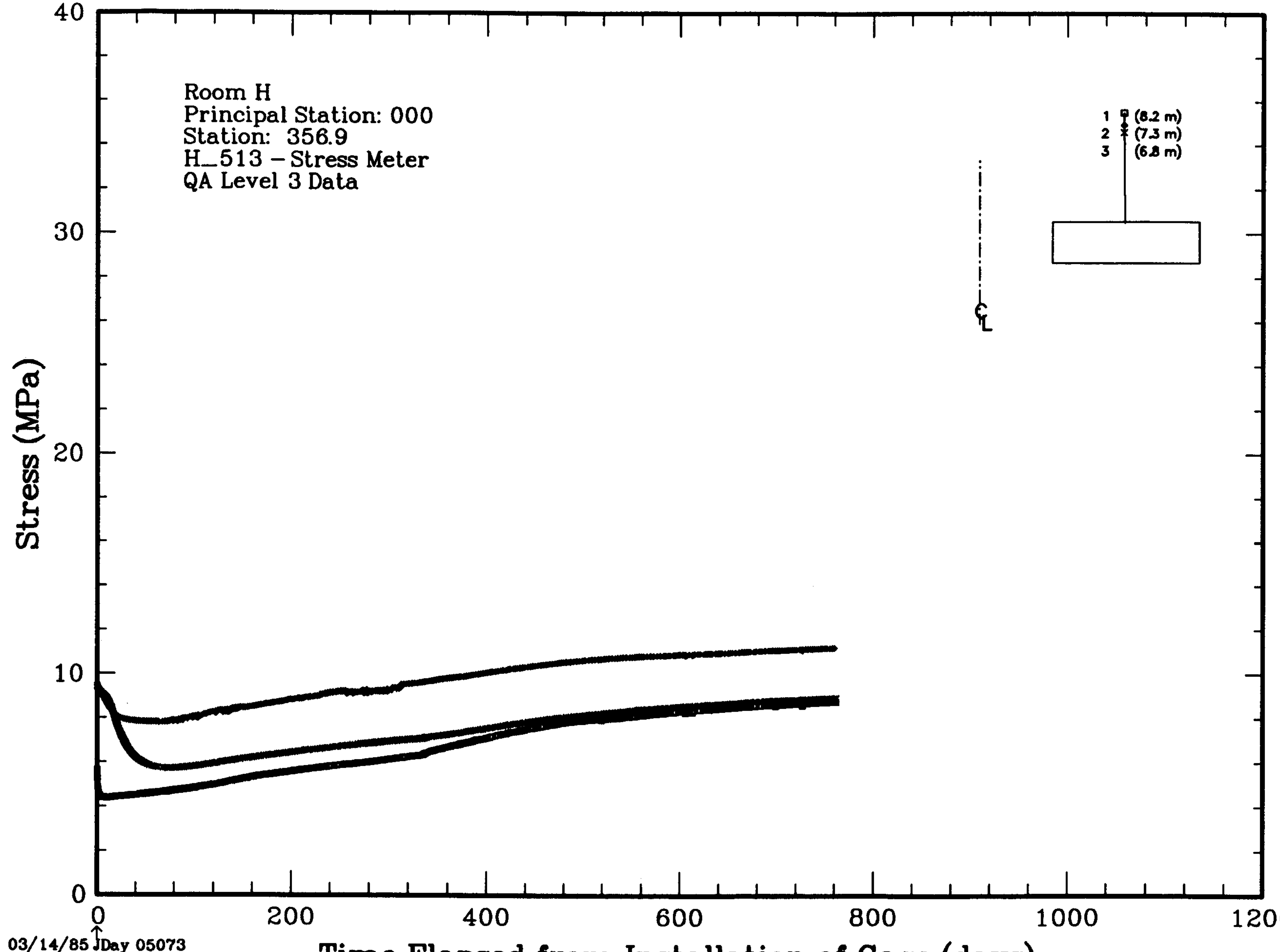

Figure 5.4.1e. BuMines Stress Meters, H 513

Table 5.4.1f. BuMines Stress Meters, H 514

Gage: H_514

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***** H_514 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] ALL THE DATA OF THIS UNIT ARE OUTSTANDING. [COMPRESSION = 6.26:1] (DEM)

***** H_514 Location *****

Principal Station 000
Station 2.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_514-1	STR	P REM	V	10.99	11.02	2.90	2.56	1.49	5.45	1.51	5.47	ROGERS	03/13/85	58-3374#04	X 0.000Y 0.000Z+1.000
H_514-2	STR	P REM	V	10.99	11.02	2.90	2.64	1.49	4.54	1.51	4.56	ROGERS	03/13/85	58-3374#08	X+0.999Y+0.051Z 0.000
H_514-3	STR	P REM	V	10.99	11.01	2.90	2.69	1.49	4.00	1.51	4.02	ROGERS	03/13/85	58-3375#08	X-0.051Y+0.999Z 0.000

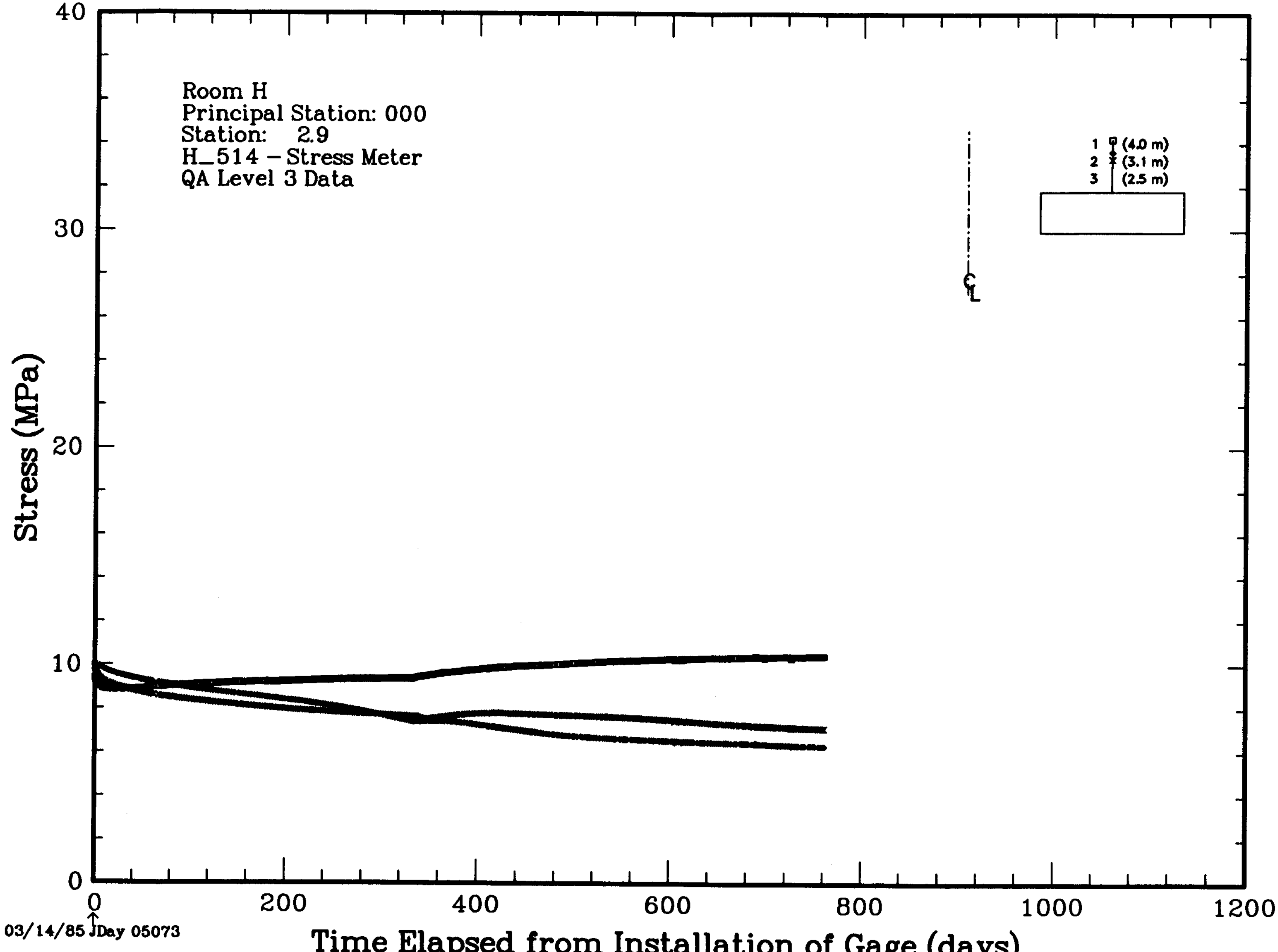

Figure 5.4.1f. BuMines Stress Meters, H 514

Table 5.4.1g. BuMines Stress Meters, H 516

Gage: H_516

****

***** H_516 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] ALL THE DATA OF THIS UNIT IS RANKED AT 10, OR OUTSTANDING. [COMPRESSION = 4.34:1] (DEM)

***** H_516 Location *****

Principal Station 000
Station 356.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_516-1	STR	P REM	V	10.93	10.95	356.91	356.58	-1.48	-9.71	-1.46	-9.69	ROGERS	04/03/85	58-3374#03	X 0.000Y 0.000Z+1.000
H_516-2	STR	P REM	V	10.93	10.95	356.91	356.61	-1.48	-8.80	-1.46	-8.78	ROGERS	04/03/85	58-3374#07	X+0.998Y-0.054Z 0.000
H_516-3	STR	P REM	V	10.93	10.94	356.91	356.62	-1.48	-8.26	-1.46	-8.24	ROGERS	04/03/85	58-3374#07	X+0.054Y+0.998Z 0.000

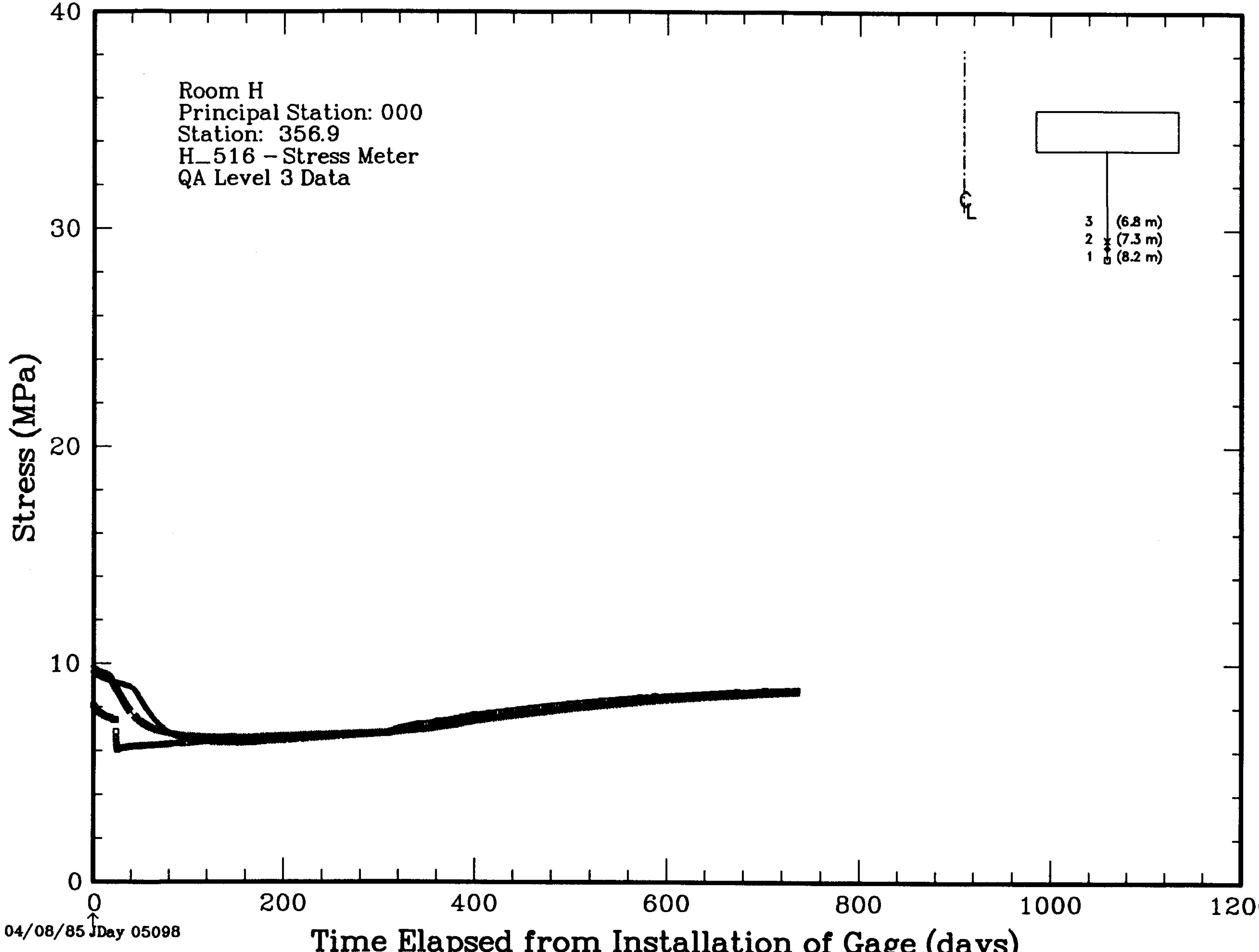

Figure 5.4.1g. BuMines Stress Meters, H 516

Table 5.4.1h. BuMines Stress Meters, H 517

Gage: H_517

****

***** H_517 PI Comments *****

08/18/87 DLH [RANK = 10(1),10(2),10(3)] ALL DATA OF THIS UNIT ARE OUTSTANDING.
[COMPRESSION = 5.05:1] (DEM)

***** H_517 Location *****

Principal Station 000
Station 3.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_517-1	STR	P REM	V	10.97	10.96	3.08	3.21	-1.40	-5.36	-1.37	-5.34	ROGERS	04/04/85	58-3374#04	X 0.000Y 0.000Z+1.000
H_517-2	STR	P REM	V	10.97	10.96	3.08	3.18	-1.40	-4.45	-1.37	-4.42	ROGERS	04/04/85	58-3374#08	X+0.998Y+0.054Z 0.000
H_517-3	STR	P REM	V	10.97	10.96	3.08	3.16	-1.40	-3.91	-1.37	-3.88	ROGERS	04/04/85	58-3374#08	X-0.054Y+0.998Z 0.000

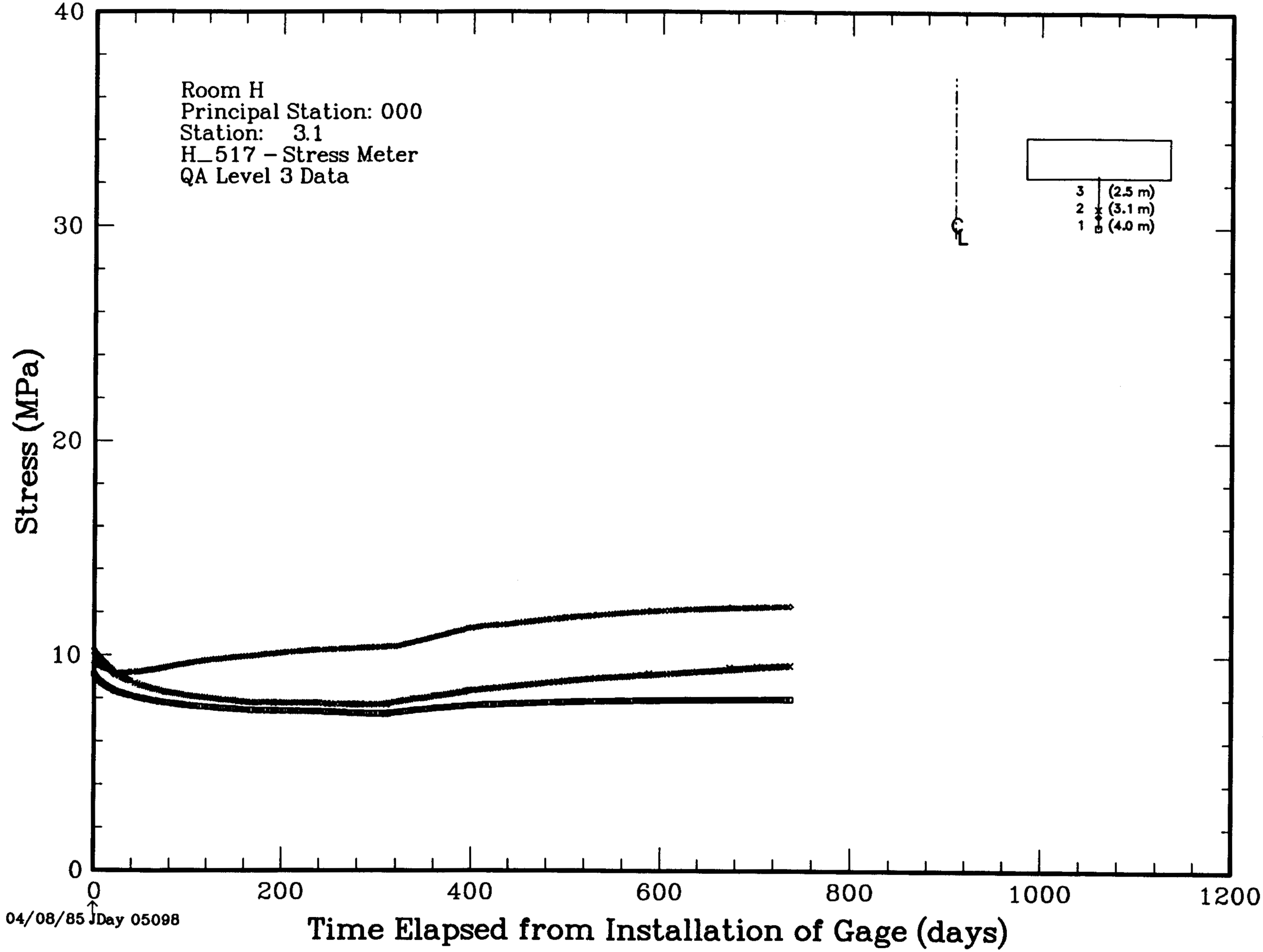

Figure 5.4.1h. BuMines Stress Meters, H 517

Table 5.4.1i. BuMines Stress Meters, H 519

Gage: H_519

****

***** H_519 PI Comments *****

08/18/87 DLH:DEM [RANK = 7(1),7(2),7(3)] ALTHOUGH THE DATA FROM THESE GAGES ARE CLEAN, THE GAGES HAD VARIOUS PROBLEMS THAT RESULTED IN FAILURE SOON AFTER THE HEATERS WERE TURNED ON. GAGE 1 SHOWS A RISE IN PRESSURE WITH HEATER ACTIVATION, WITH A MODERATE DROP OF PRESSURE 20 DAYS THEREAFTER AND A MARKED DROP OF PRESSURE 100 DAYS THEREAFTER. GAGE 1 APPARENTLY FAILED COMPLETELY AT DAY 395. GAGE 2 HAD THE PRESSURE INTENTIONALLY DECREASED AT DAY 262 AND AGAIN AT DAY 357; CORRECTIONS FOR THE INTENTIONAL PRESSURE DECREASED ARE NOT CURRENTLY POSSIBLE. GAGE 2 FAILED AT DAY 403. GAGE 3 SHOWS A RISE IN PRESSURE WITH HEATER ACTIVATION, WITH A SEVERE DROP IN PRESSURE SOON AFTERWARDS AND APPARENT FAILURE AT DAY 346. [COMPRESSION = 1.15:1] (DEM)

***** H_519 Location *****

Principal Station 180
Station 183.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_519-1	STR	P REM	H	5.56	-0.54	182.97	182.11	-0.04	-0.04	0.01	0.01	ROGERS	03/22/85	58-3374#03	X+0.999Y+0.052Z 0.000
H_519-2	STR	P REM	H	5.56	0.37	182.97	184.42	-0.04	-0.04	0.01	0.01	ROGERS	03/22/85	58-3374#07	X 0.000Y 0.000Z+1.000
H_519-3	STR	P REM	H	5.56	0.92	182.97	183.34	-0.04	-0.04	0.01	0.01	ROGERS	03/22/85	58-3374#07	X-0.052Y+0.999Z 0.000

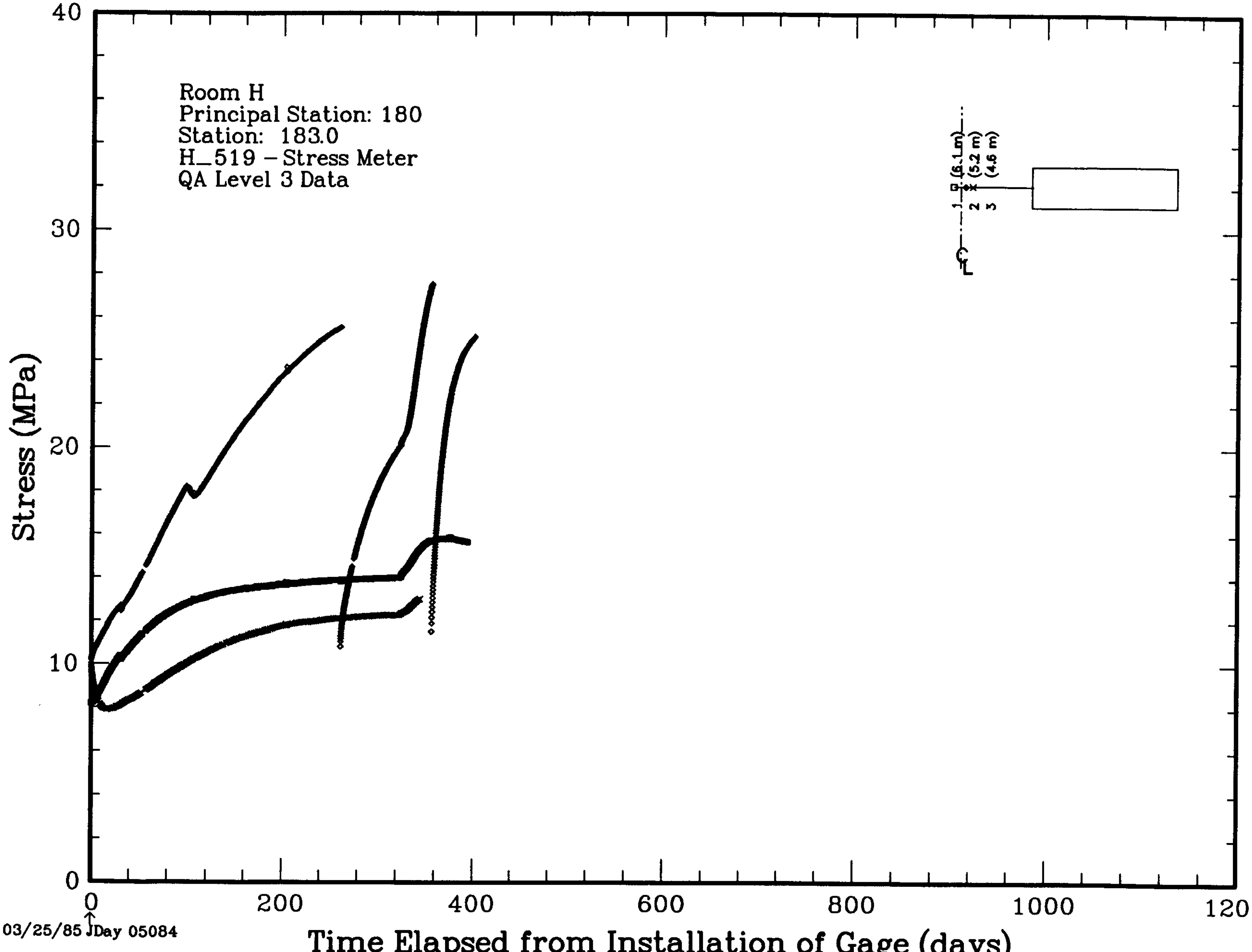

Figure 5.4.1i. BuMines Stress Meters, H 519

Table 5.4.1j. BuMines Stress Meters, H 520

Gage: H_520

****

***** H_520 PI Comments *****

08/20/87 DLH [RANK = 7(1),7(2),7(3)] THE DATA OF THESE GAGES ARE ALL VERY GOOD; HOWEVER, THE GAGES ALL APPARENTLY FAILED ABOUT 75 DAYS AFTER HEATER TURN ON. GAGE 1, 2, AND 3 FAILED AT DAY 398, 409, AND 409, RESPECTIVELY. THE REASONS FOR FAILURES IS UNKNOWN. [COMPRESSION = 2.55:1] (DEM)

***** H_520 Location *****

Principal Station 180
Station 176.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_520-1	STR	P REM	H	5.56	2.21	176.90	176.64	0.01	0.01	0.05	0.05	ROGERS	03/21/85	58-3374#04	X+0.998Y-0.054Z 0.000
H_520-2	STR	P REM	H	5.56	3.12	176.90	176.72	0.01	0.01	0.05	0.05	ROGERS	03/21/85	58-3374#08	X+0.054Y+0.998Z 0.000
H_520-3	STR	P REM	H	5.56	3.66	176.90	176.83	0.01	0.01	0.05	0.05	ROGERS	03/21/85	58-3374#08	X 0.000Y 0.000Z+1.000

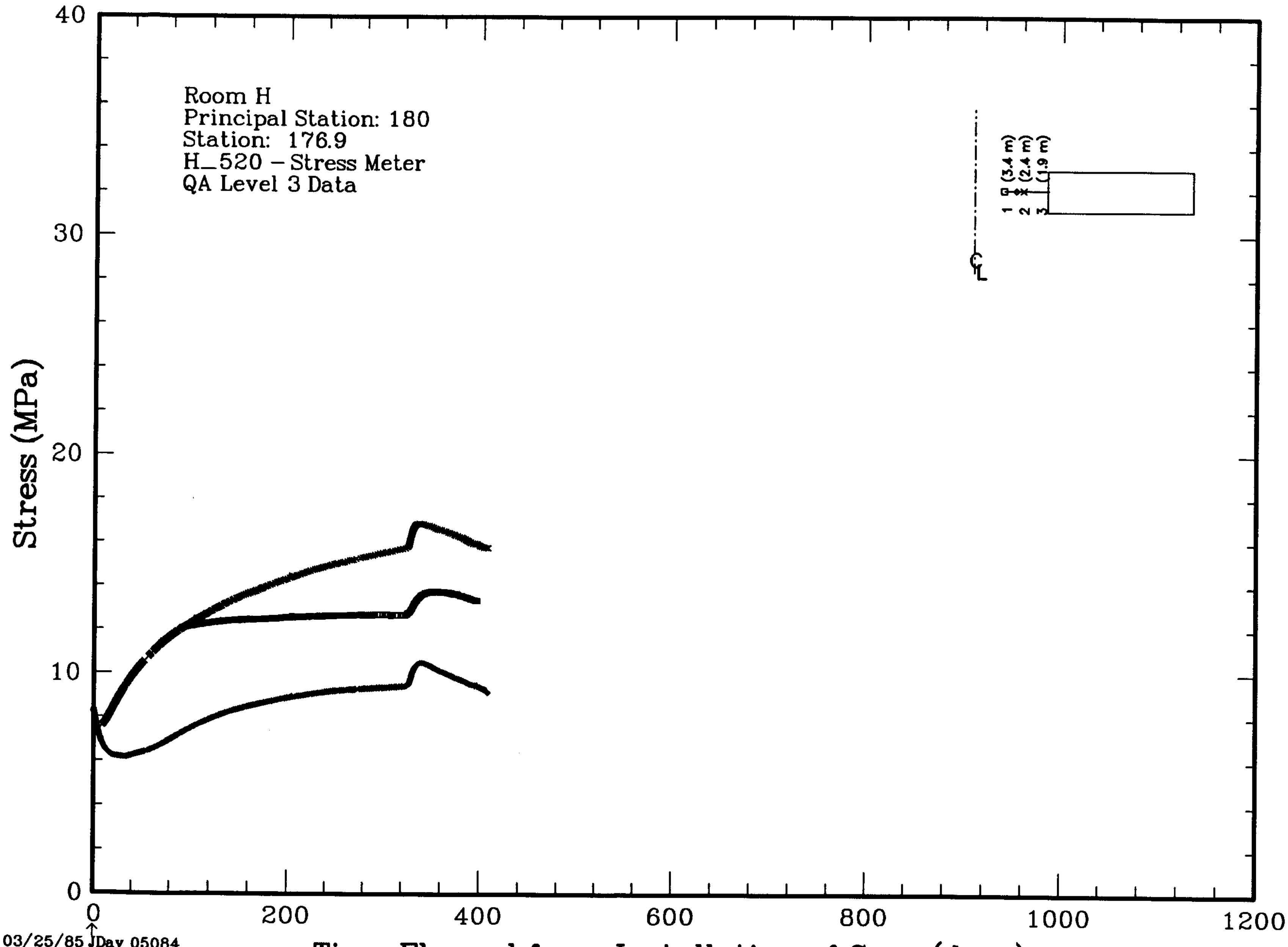

Figure 5.4.1j. BuMines Stress Meters, H 520

Table 5.4.1k. BuMines Stress Meters, H 523

Gage: H_523

****

***** H_523 PI Comments *****

09/21/87 DLH:DEM [RANK = 10(1),9(2),10(3)] THE DATA QUALITY OF THIS UNIT IS OUTSTANDING, EXCEPT THAT GAGE 2 LOST PRESSURE AT DAY 587 FOR UNKNOWN REASONS. A REPRESSURIZATION SEEMS TO BE HOLDING AND UNTIL THIS CAN BE CLEARLY INTERPRETED AS A GAGE FAILURE OR NOT, THE DATA WILL BE RETAINED. [COMPRESSION = 3.70:1] (DEM)

***** H_523 Location *****

Principal Station 180
Station 182.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_523-1	STR	P REM	H	16.30	24.53	182.95	182.97	-0.03	0.01	0.02	0.05	ROGERS	03/25/85	58-3374#03	X+0.999Y+0.051Z 0.000
H_523-2	STR	P REM	H	16.30	23.61	182.95	182.97	-0.03	0.01	0.02	0.05	ROGERS	03/25/85	58-3374#07	X 0.000Y 0.000Z+1.000
H_523-3	STR	P REM	H	16.30	23.07	182.95	182.96	-0.03	0.00	0.02	0.05	ROGERS	03/25/85	58-3374#07	X-0.051Y+0.999Z 0.000

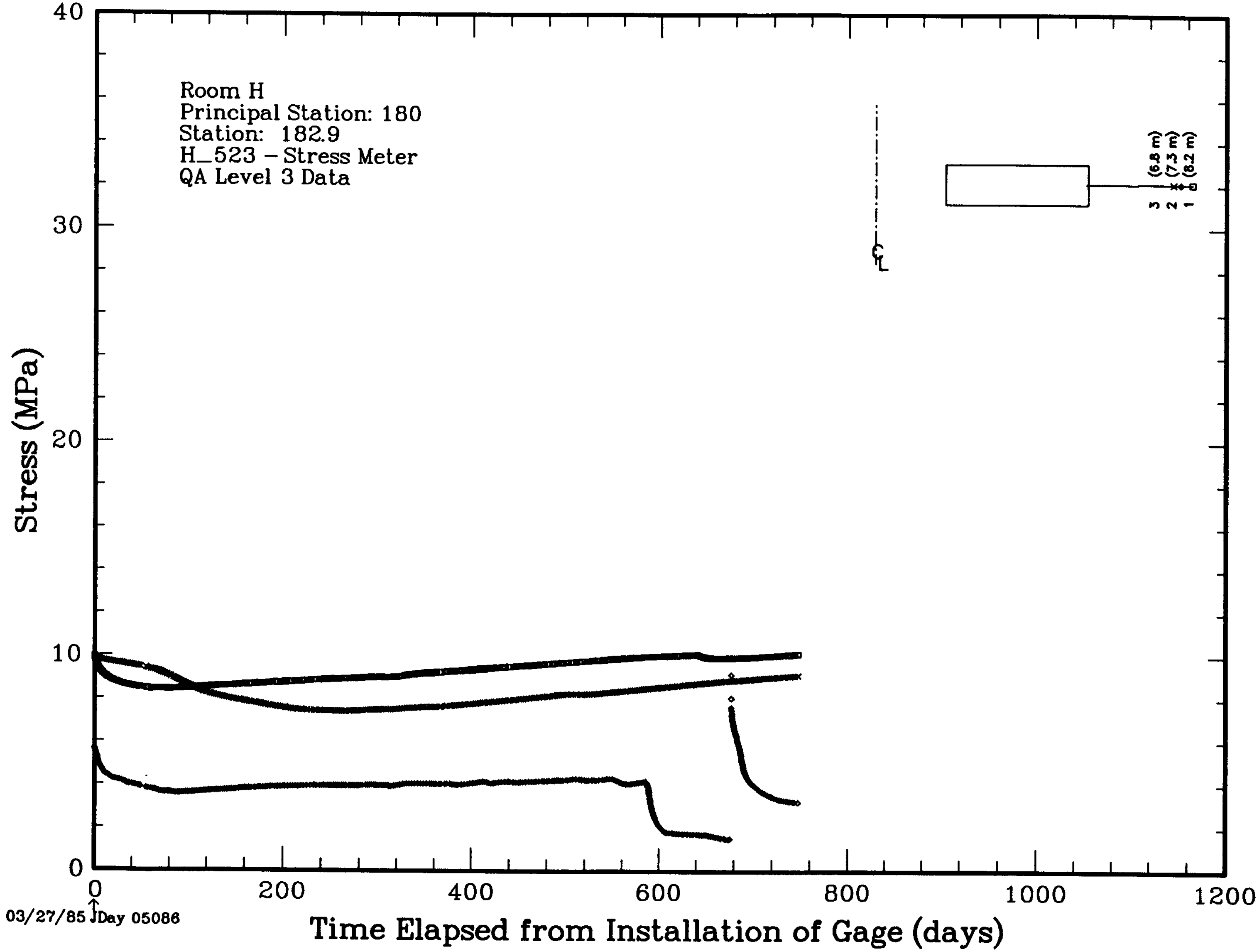

Figure 5.4.1k. BuMines Stress Meters, H 523

Table 5.4.11. BuMines Stress Meters, H 524

Gage: H_524

****

***** H_524 PI Comments *****

09/21/87 DLH [RANK = 10(1),10(2),10(3)] THE DATA OF THE ENTIRE UNIT ARE OUTSTANDING. [COMPRESSION = 3.44:1] (DEM)

***** H_524 Location *****

Principal Station 180
Station 177.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_524-1	STR	P REM	H	16.33	20.29	176.99	176.96	0.01	-0.02	0.05	0.03	ROGERS	03/26/85	58-3374#04	X+0.999Y-0.053Z 0.000
H_524-2	STR	P REM	H	16.33	19.38	176.99	176.97	0.01	-0.01	0.05	0.04	ROGERS	03/26/85	58-3374#08	X 0.000Y 0.000Z+1.000
H_524-3	STR	P REM	H	16.33	18.84	176.99	176.97	0.01	-0.01	0.05	0.04	ROGERS	03/26/85	58-3374#08	X+0.053Y+0.999Z 0.000

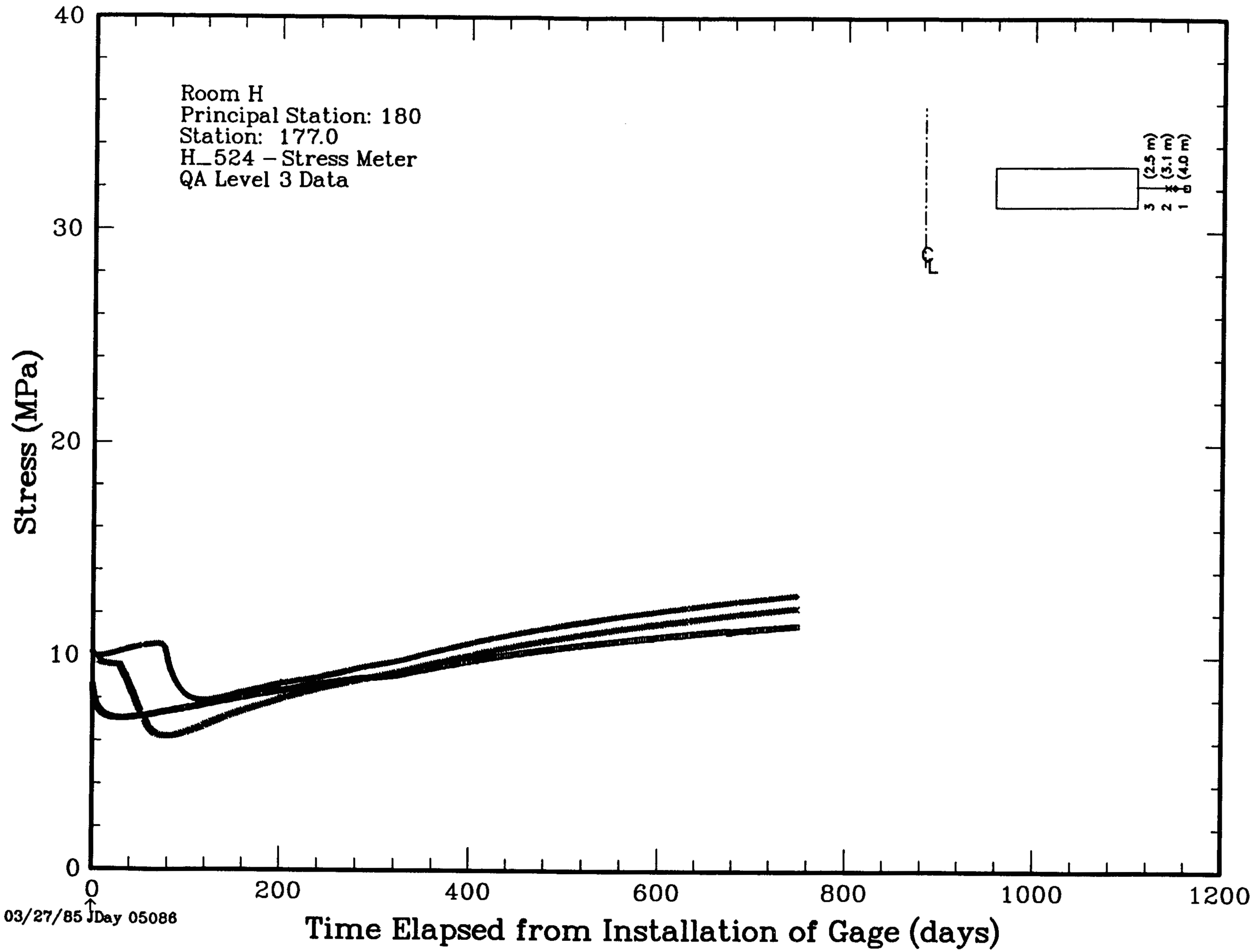

Figure 5.4.11. BuMines Stress Meters, H 524

Table 5.4.1m. BuMines Stress Meters, H 532

Gage: H_532

****

***** H_532 PI Comments *****

08/20/87 DLH:DEM [RANK = 7(1),7(2),7(3)] THE DATA OF ALL GAGES IS VERY GOOD; HOWEVER, AGAIN APPARENT GAGE FAILURE TERMINATES THE RECORDS AFTER HEATER TURN ON FOR TWO OF THE GAGES. GAGE 2 HAD THE PRESSURE INTENTIONALLY DECREASED AT DAY 263, 368, AND 414; NO CORRECTIVE SHIFTS ARE POSSIBLE AT THIS TIME. GAGE 1, 2, AND 3 APPARENTLY LOST PRESSURE DUE TO GAGE FAILURE ON DAY 361, 457, AND 419, RESPECTIVELY. [COMPRESSION = 1.73:1] (DEM)

***** H_532 Location *****

Principal Station 000
Station   3.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_532-1	STR	P REM	H	5.57	1.30	3.12	2.34	-0.05	-0.07	-0.03	-0.04	ROGERS	03/11/85	58-3374#04	X+0.998Y+0.054Z 0.000
H_532-2	STR	P REM	H	5.57	2.22	3.12	2.71	-0.05	-0.06	-0.03	-0.04	ROGERS	03/11/85	58-3374#08	X 0.000Y 0.000Z+1.000
H_532-3	STR	P REM	H	5.57	2.76	3.12	2.88	-0.05	-0.06	-0.03	-0.04	ROGERS	03/11/85	58-3374#08	X-0.054Y+0.998Z 0.000

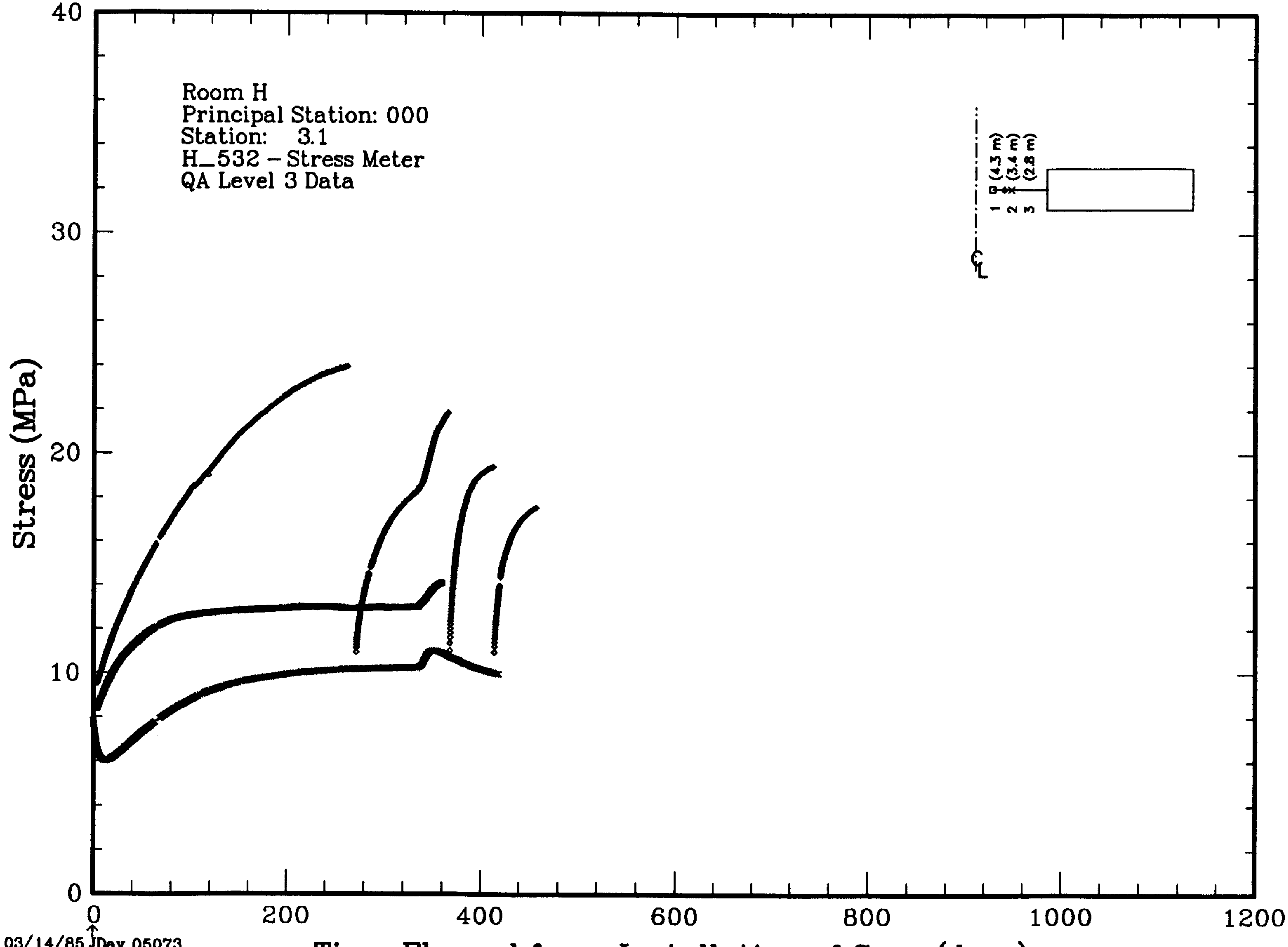

Figure 5.4.1m. BuMines Stress Meters, H 532

Table 5.4.1n. BuMines Stress Meters, H 533

Gage: H_533

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***** H_533 PI Comments *****

08/20/87 DLH [RANK = 7(1),7(2),9(3)] THE DATA QUALITY IS HIGH ON ALL OF THESE GAGES. GAGE 1 AND 2 APPARENTLY FAILED OR HAD LOSS OF PRESSURE AFTER THE HEATERS WERE TURNED ON. GAGE 2 HAD A BAD TRANSDUCER BETWEEN DAY 246 AND 271, WHICH RESULTED IN DELETED DATA. GAGE 1 AND 2 APPARENTLY FAILED AT DAY 375 AND 389, RESPECTIVELY. INTERESTINGLY GAGE 3, AFTER A TRANSIENT DUE TO THE HEATING, APPEARS TO BE GIVING GOOD DATA WITHOUT FAILURE. [COMPRESSION = 1.43:1] (DEM)

***** H_533 Location *****

Principal Station 000
Station 357.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_533-1	STR	P REM	H	5.56	3.12	357.03	357.23	-0.05	-0.06	-0.03	-0.04	ROGERS	03/12/85	58-3374#04	X+0.999Y-0.052Z 0.000
H_533-2	STR	P REM	H	5.56	4.04	357.03	357.12	-0.05	-0.06	-0.03	-0.03	ROGERS	03/12/85	58-3374#08	X 0.000Y 0.000Z+1.000
H_533-3	STR	P REM	H	5.56	4.58	357.03	357.08	-0.05	-0.05	-0.03	-0.03	ROGERS	03/12/85	58-3374#08	X+0.052Y+0.999Z 0.000

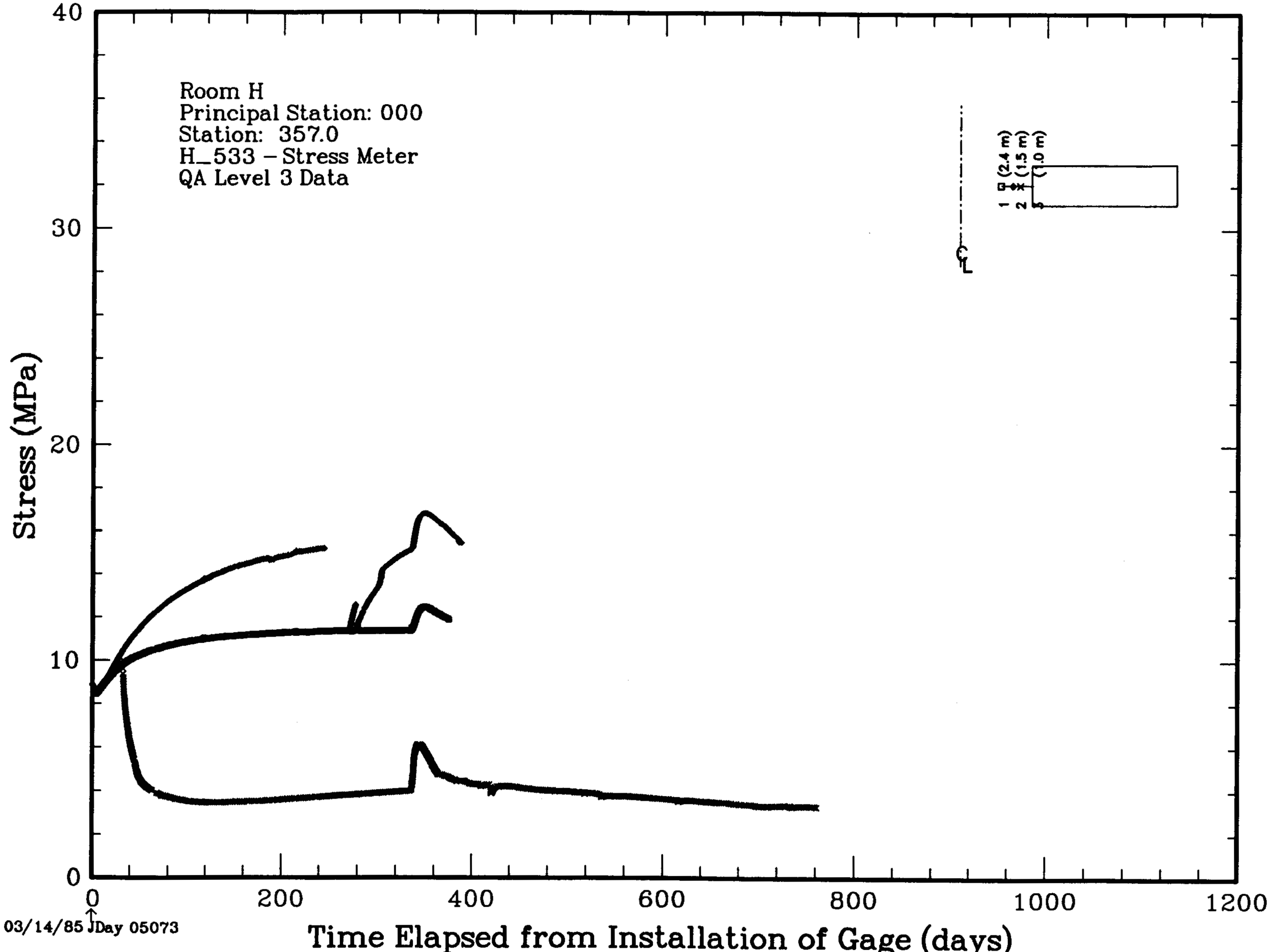

Figure 5.4.1n. BuMines Stress Meters, H 533

Table 5.4.1o. BuMines Stress Meters, H 535

Gage: H_535

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***** H_535 PI Comments *****

09/21/87 DLH:DEM [RANK = 10(1),10(2),9(2)] THE UNIT HAS OUTSTANDING DATA, EXCEPT FOR THE INSTALLATION OF A NEW TRANSDUCER IN GAGE 3. THE DE- AND REPRESSURIZATION AT DAY 303 IS EVIDENT IN THE RECORD. AT THIS TIME IT IS NOT CLEAR WHETHER OR NOT THE SUBSEQUENT DATA SHOULD BE SHIFTED SO THIS ACTION WAS DEFERRED UNTIL LATER. [COMPRESSION = 3.47:1] (DEM)

***** H_535 Location *****

Principal Station 000
Station 3.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_535-1	STR	P REM	H	16.40	24.63	3.05	3.05	-0.04	-0.05	-0.02	-0.02	ROGERS	03/07/85	58-3374#03	X+0.999Y+0.053Z 0.000
H_535-2	STR	P REM	H	16.40	23.72	3.05	3.06	-0.04	-0.04	-0.02	-0.02	ROGERS	03/07/85	58-3374#07	X 0.000Y 0.000Z+1.000
H_535-3	STR	P REM	H	16.40	23.18	3.05	3.05	-0.04	-0.04	-0.02	-0.02	ROGERS	03/07/85	58-3374#07	X-0.053Y+0.999Z 0.000

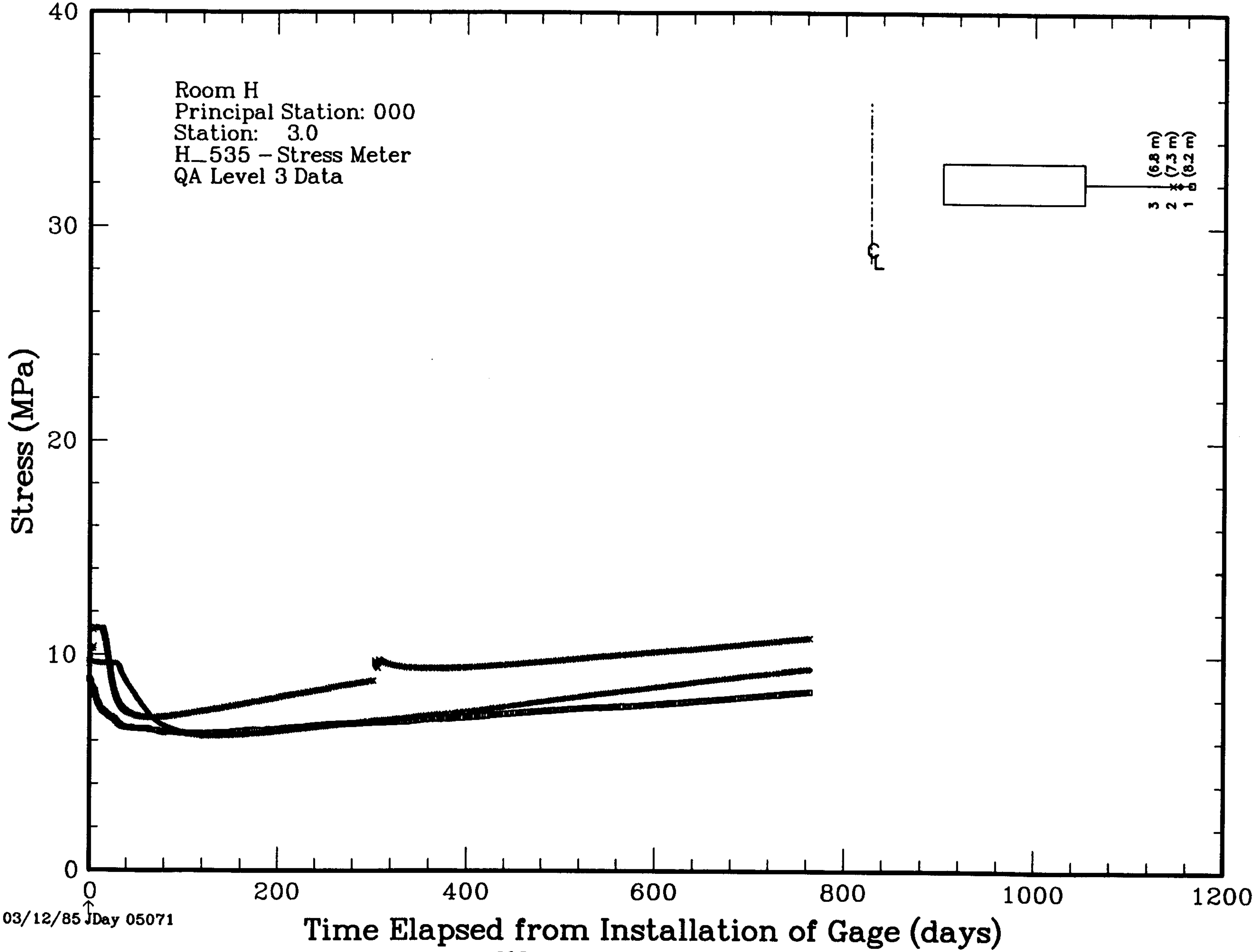

Figure 5.4.1o. BuMines Stress Meters, H 535

Table 5.4.1p. BuMines Stress Meters, H 536

Gage: H_536

****

***** H_536 PI Comments *****

09/21/87 DLH [RANK = 8(1),8(2),9(3)] WHILE THE DATA ARE CLEAN FROM THIS UNIT, THERE ARE SOME GRADUAL SHIFTS IN LEVEL, WHICH CANNOT BE INTERPRETED AT THIS TIME, THAT DO NOT APPEAR TO BE FAILURE OF THE GAGES AS A CONSEQUENCE, THE RANKING OF THE GAGES HAS BEEN REDUCED SOMEWHAT. [COMPRESSION = 2.99:1] (DEM)

***** H_536 Location *****

Principal Station 000
Station 357.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_536-1	STR	P REM	H	16.44	20.40	357.02	357.00	-0.03	-0.03	0.00	0.00	ROGERS	03/08/85	58-3374#04	X+0.999Y-0.052Z 0.000
H_536-2	STR	P REM	H	16.44	19.49	357.02	357.01	-0.03	-0.03	0.00	0.00	ROGERS	03/08/85	58-3374#08	X 0.000Y 0.000Z+1.000
H_536-3	STR	P REM	H	16.44	18.95	357.02	357.01	-0.03	-0.03	0.00	0.00	ROGERS	03/08/85	58-3374#08	X+0.052Y+0.999Z 0.000

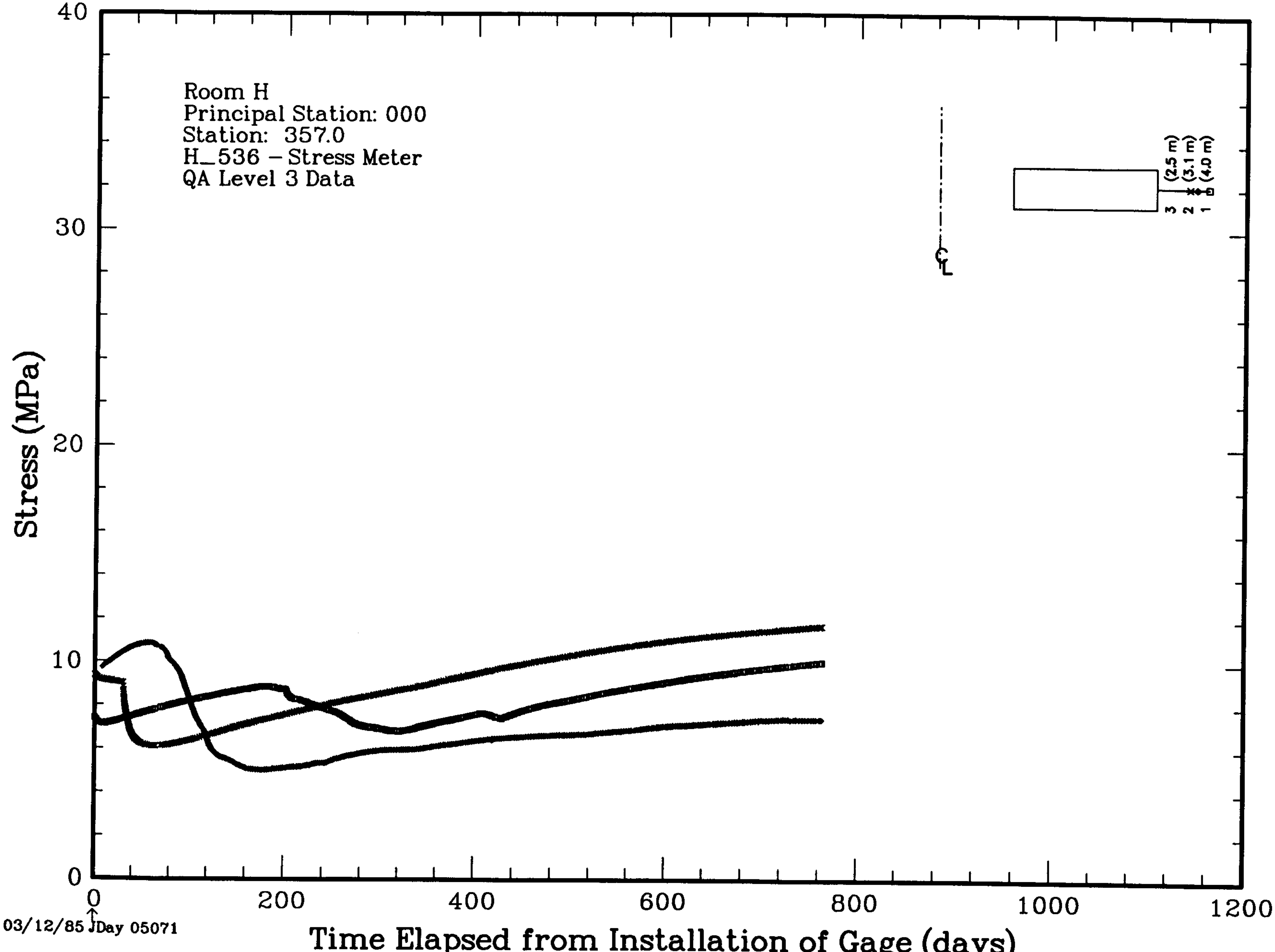

Figure 5.4.1p. BuMines Stress Meters, H 536

Table 5.4.1q. BuMines Stress Meters, H 537

Gage: H_537

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***** H_537 PI Comments *****

09/22/87 DLH:DEM [RANK = 10(1),10(2),10(3)] THE QUALITY OF THE DATA OF THIS UNIT IS OUTSTANDING, EVEN WHEN THE PRESSURE LOSSES OCCURRED. WHILE THE LOSS OF PRESSURE FOR GAGE 1 AT DAY 682, GAGE 2 AT DAY 658, AND GAGE 3 AT DAY 724 MAY BE FAILURE, THE PRESSURES HAVE NOT FALLEN TO ZERO. AS A CONSEQUENCE THE RECORDS ARE REPORTED. IT IS CLEAR THAT THE QUALITY OF THE DATA AFTER THE ABOVE DATES HAS DIMINSHED. [COMPRESSION = 2.10:1] (DEM)

***** H_537 Location *****

Principal Station 180
Station 181.6

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_537-1	STR	P REM	D	5.98	-0.30	181.65	66.45	1.45	9.25	1.50	9.30	ROGERS	03/19/85	58-3374#03	X+0.598Y+0.029Z+0.801
H_537-2	STR	P REM	D	5.98	0.72	181.65	201.55	1.45	8.52	1.50	8.57	ROGERS	03/19/85	58-3374#07	X+0.801Y 0.000Z-0.598
H_537-3	STR	P REM	D	5.98	1.02	181.65	194.57	1.45	8.09	1.50	8.13	ROGERS	03/19/85	58-3374#07	X-0.029Y+1.000Z 0.000

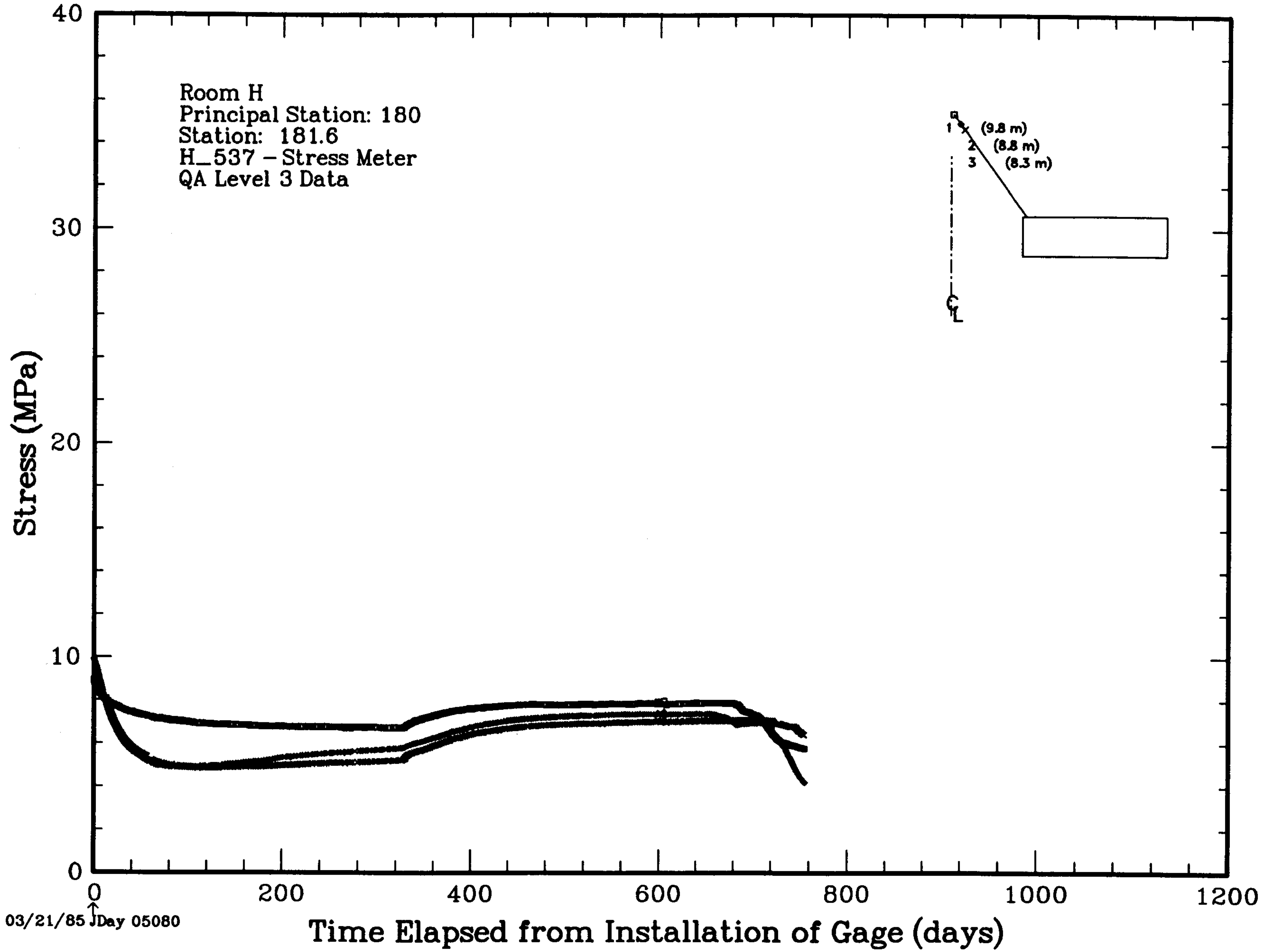

Figure 5.4.1q. BuMines Stress Meters, H 537

Table 5.4.1r. BuMines Stress Meters, H 538

Gage: H_538

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***** H_538 PI Comments *****

09/22/87 DLH:DEM [RANK = 7(1),7(2),7(3)] THE QUALITY OF THE ENTIRE UNIT IS REDUCED BY UNEXPLAINED SHIFTS IN THE RECORDS. LOSS OF PRESSURE BEGINS FOR GAGE 1 AT DAY 414, GAGE 2 AT DAY 440, AND GAGE 3 AT DAY 448. IN GAGE 1 AND 2, THE PRESSURE FELL TO ZERO AND THE GAGES WERE EVENTUALLY DISCONNECTED FROM THE REMOTE SYSTEM ON DAY 530. GAGE 3 WAS REPRESSURIZED THREE TIMES AND DOES CURRENTLY HAVE SOME PRESSURE READING. [COMPRESSION 1.55:1] (DEM)

***** H_538 Location *****

Principal Station 000
Station 0.2

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_538-1	STR	P REM	D	5.80	-0.25	0.20	354.77	1.26	4.68	1.29	4.70	ROGERS	03/11/85	58-3374#03	X+0.871Y+0.003Z-0.492
H_538-2	STR	P REM	D	5.80	0.55	0.20	2.40	1.26	4.23	1.29	4.26	ROGERS	03/11/85	58-3374#07	X+0.492Y 0.000Z+0.871
H_538-3	STR	P REM	D	5.80	1.01	0.20	1.29	1.26	3.97	1.29	3.99	ROGERS	03/11/85	58-3374#07	X-0.003Y+1.000Z 0.000

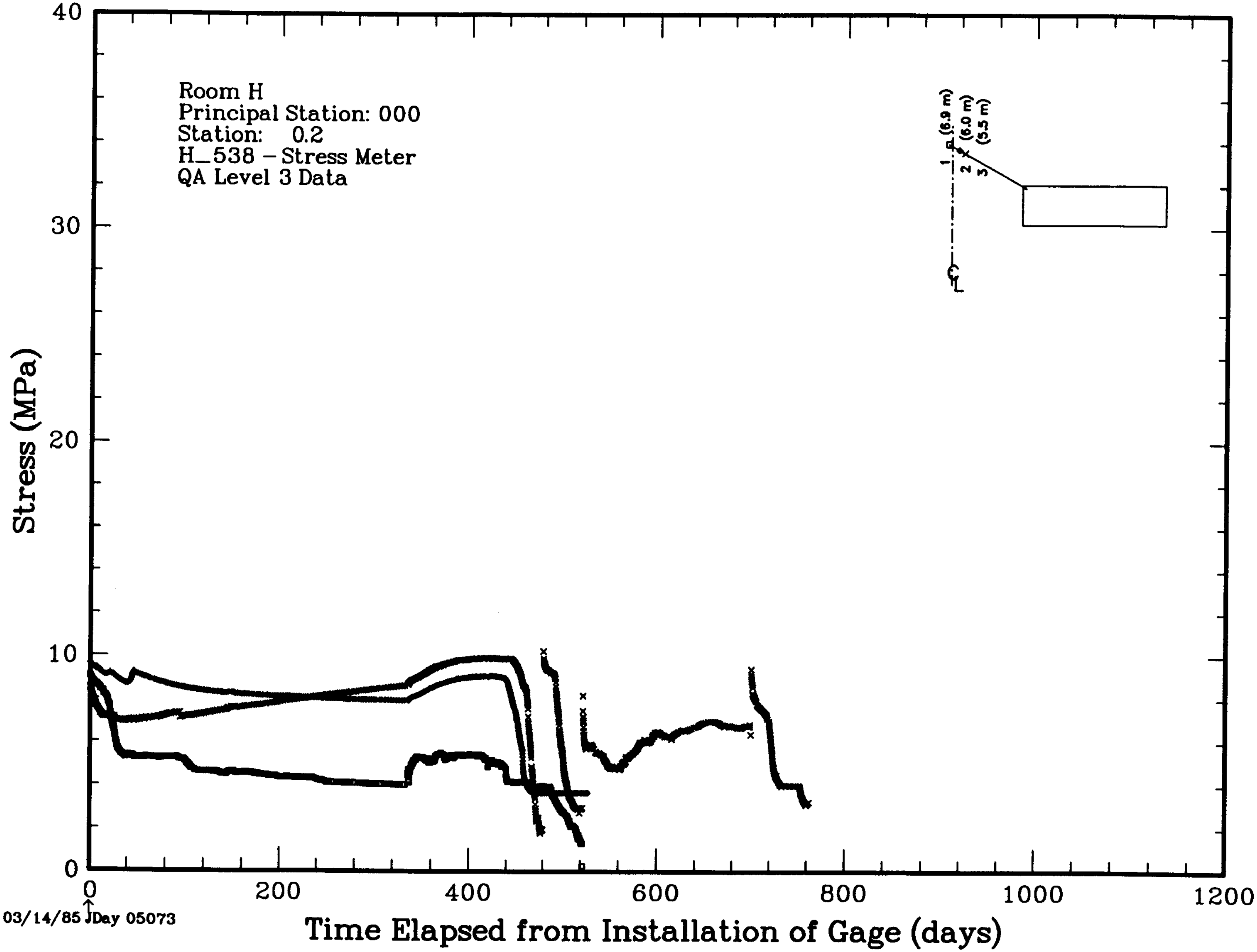

Figure 5.4.1r. BuMines Stress Meters, H 538

Table 5.4.1s. BuMines Stress Meters, H 543

Gage: H_543

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***** H_543 PI Comments *****

09/22/87 DLH:DEM [RANK = 9(1),9(2),9(3)] THE RATHER FEW UNEXPLAINED SHIFTS IN THE RECORDS CAUSED THE RANK TO BE REDUCED; HOWEVER, THE DATA ARE STILL EXCEPTIONAL. ALL GAGES LOST PRESSURE, STARTING WITH GAGE 3 AT DAY 408, GAGE 1 AT DAY 453, AND GAGE 2 AT DAY 500. GAGE 2 STILL MAINTAINS SOME PRESSURE. GAGE 3 WAS DISCONTINUED FROM THE REMOTE SYSTEM ON DAY 509 AND GAGE 1 ON DAY 595. [COMPRESSION = 2.59:1] (DEM)

***** H_543 Location *****

Principal Station 180
Station 181.6

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_543-1	STR	P REM	D	6.03	-0.14	181.58	146.14	-1.43	-9.59	-1.39	-9.54	ROGERS	03/27/85	58-3374#03	X-0.602Y+0.028Z+0.799
H_543-2	STR	P REM	D	6.03	0.44	181.58	191.35	-1.43	-8.86	-1.39	-8.81	ROGERS	03/27/85	58-3374#07	X+0.799Y 0.000Z+0.602
H_543-3	STR	P REM	D	6.03	0.77	181.58	186.76	-1.43	-8.42	-1.39	-8.38	ROGERS	03/27/85	58-3374#07	X-0.028Y+1.000Z 0.000

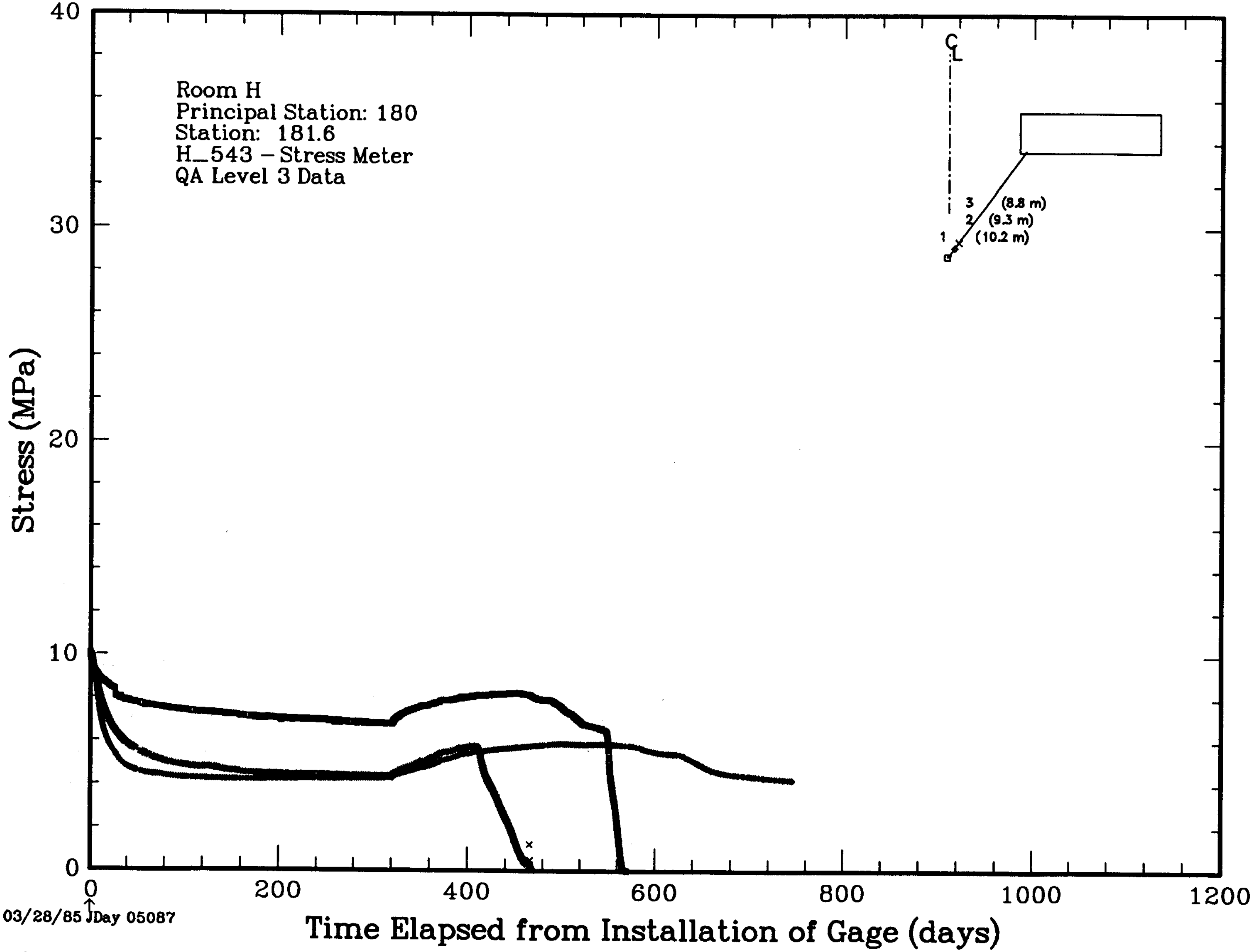

Figure 5.4.1s. BuMines Stress Meters, H 543

Table 5.4.1t. BuMines Stress Meters, H 544

Gage: H_544

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***** H_544 PI Comments *****

09/22/87 DLH:DEM [RANK = 8(1),9(2),9(3)] WHILE THE DATA QUALITY IS EXCELLENT, OR BETTER, ALL THE GAGES LOST PRESSURE IN VERY ABRUPT WAYS. IN ADDITION, GAGE 1 HAS SOME UNEXPLAINED SHIFTS AND PEAKS IN THE RECORD. LOSS OF PRESSURE WAS OBSERVED IN GAGE 1 AT DAY 449, GAGE 2 AT DAY 471, AND GAGE 3 AT DAY 440. GAGE 2 WAS REPRESSURIZED AT DAY 522. GAGE 1 AND GAGE 3 WERE DISCONTINUED FROM THE REMOTE SYSTEM ON DAY 460, AND GAGE 2 WAS DISCONTINUED ON DAY 662.
[COMPRESSION = 2.71:1] (DEM)

***** H_544 Location *****

Principal Station 000
Station 360.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_544-1	STR	P REM	D	5.67	-0.36	359.95	352.04	-1.44	-4.89	-1.41	-4.86	ROGERS	03/12/85	58-3374#03	X+0.868Y-0.001Z+0.497
H_544-2	STR	P REM	D	5.67	0.44	359.95	5.39	-1.44	-4.44	-1.41	-4.41	ROGERS	03/12/85	58-3374#07	X-0.497Y 0.000Z+0.868
H_544-3	STR	P REM	D	5.67	0.90	359.95	2.42	-1.44	-4.17	-1.41	-4.15	ROGERS	03/12/85	58-3374#07	X+0.001Y+1.000Z 0.000

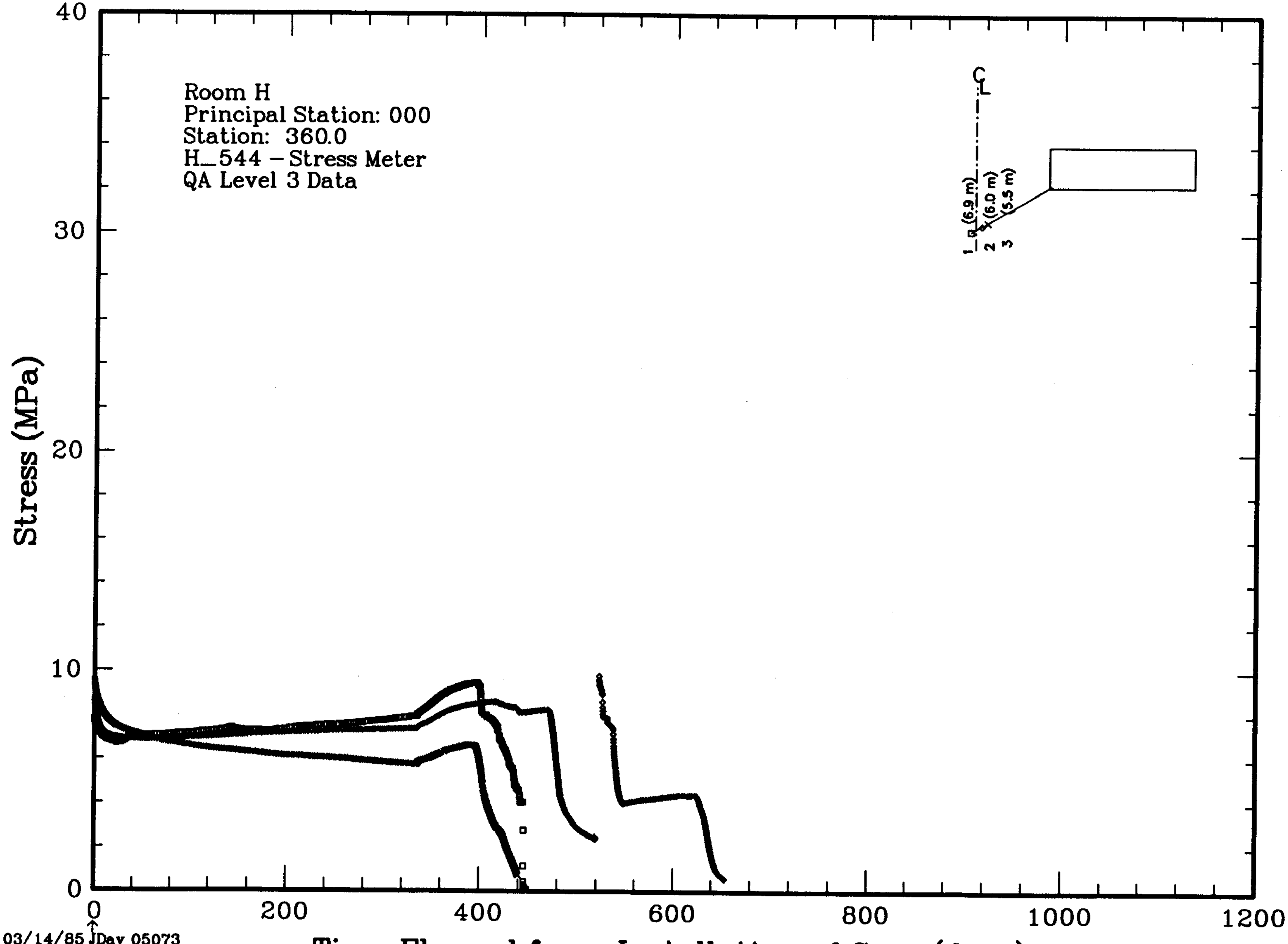

Figure 5.4.1t. BuMines Stress Meters, H 544

Table 5.4.2a. SGS Stress Meters, H 549

Gage: H_549

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***** H_549 PI Comments *****

09/23/87 DLH:DEM [RANK = 10(10,10(2),10(3)] THIS UNIT WAS ONE OF THOSE EMPLACED IN THE PILLAR MATERIAL PRIOR TO EXCAVATION OF THE H ROOM. THE SLOW CHANGES OF STRESS AROUND THE ROOM H ENTRY IS APPARENT, AS IS THE SUDDEN CHANGE OF STRESS WHEN THE ROOM H WAS EXCAVATED BEGINNING ON DAY 206 (JDAY 5024) AND ENDING ON DAY 237 (JDAY 5055). THE DATA COME TO A NEW PLATEAU, MAINTAINED FOR SOME PERIOD OF TIME. EVENTUALLY THE DATA SHOW A DECLINE IN STRESS OR AN ERRATIC RESPONSE. THIS CAUSED GAGE 1 TO BE DISCONTINUED FROM REMOTE RECORDING ON DAY 413, GAGE 2 TO SHOW A STRESS DECLINE BEGINNING WITH DAY 500, AND GAGE 3 TO DEVELOP ERRATIC RESPONSE BEGINNING ON DAY 515. [COMPRESSION = 1.81:1] (DEM)

***** H_549 Location *****

Principal Station 090
Station 92.8

Gage Number	Gage Type	Rec	Dir	Gage Coordinates Prin Stat R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_549-1	STR	T REM	H	5.73	-1.59	92.84	94.84	-0.56	-0.50	-0.48	-0.42	SPCL.EN	06/27/84	58-0489#01	X-0.499Y-0.049Z+0.866
H_549-2	STR	T REM	H	5.73	-1.29	92.84	95.03	-0.56	-0.50	-0.48	-0.42	SPCL.EN	06/27/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_549-3	STR	T REM	H	5.73	-0.98	92.84	95.70	-0.56	-0.51	-0.48	-0.43	SPCL.EN	06/27/84	58-0489#01	X+0.499Y+0.049Z+0.866

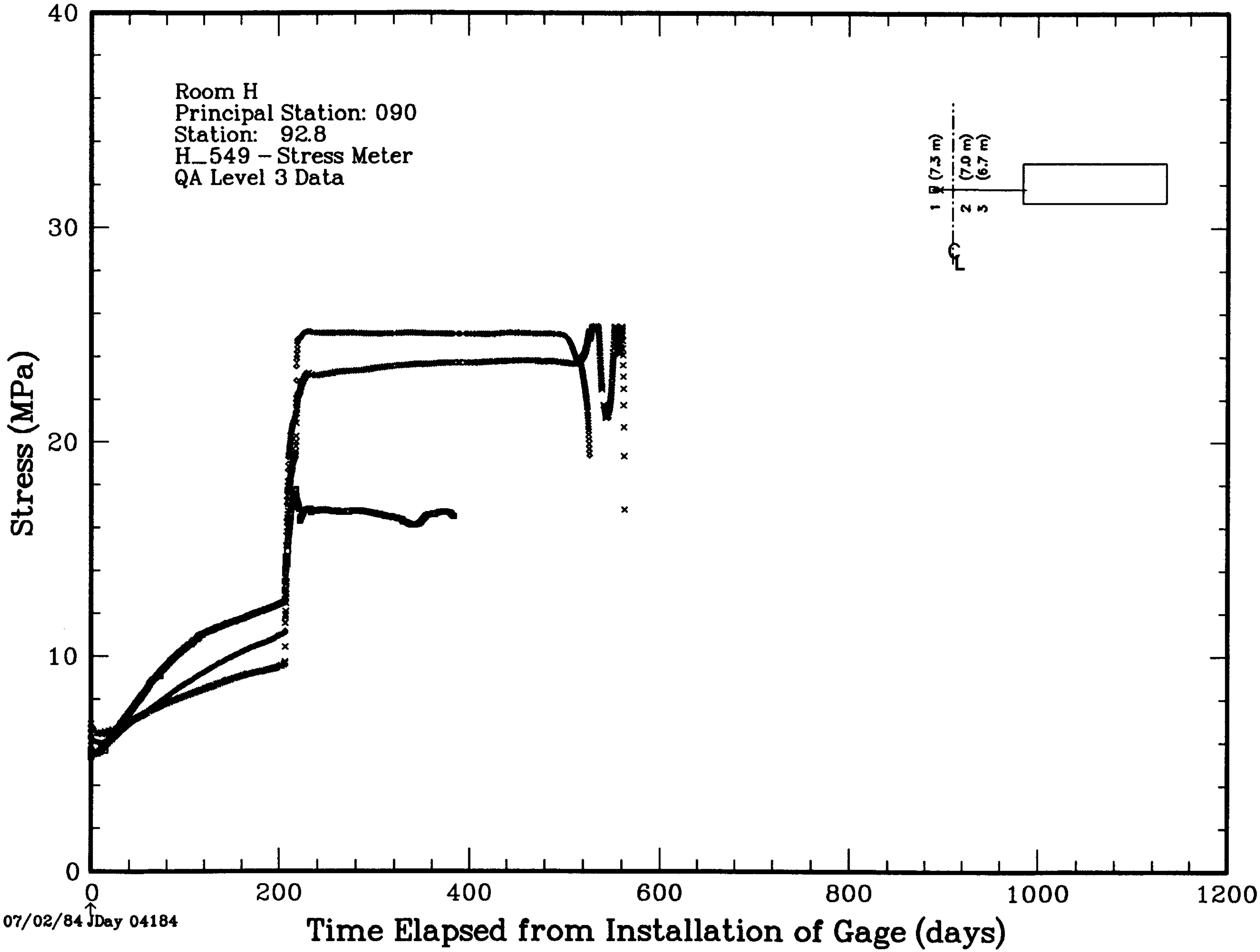

Figure 5.4.2a. SGS Stress Meters, H 549

Table 5.4.2b. SGS Stress Meters, H 550

Gage: H_550

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***** H_550 PI Comments *****

09/23/87 DLH:DEM [RANK = 9(1),8(2),9(3)] THIS UNIT WAS ONE OF THOSE EMPLACED IN THE PILLAR MATERIAL PRIOR TO EXCAVATION OF THE H ROOM. THE DATA SHOW THE GRADUAL CHANGES RESULTING FROM THE STRESS FIELD AROUND THE ROOM H ENTRY AND THEN THE MARKED CHANGES RESULTING FROM THE EXCAVATION OF THE H ROOM. ROOM EXCAVATION STARTED ON DAY 207 (JDAY 5024) AND ENDED ON DAY 237 (JDAY 5055). THE DATA QUALITY, WHILE EITHER EXCELLENT OR EXCEPTIONAL, SHOW A LOSS OF STRESS QUITE SOON AFTER THE MINING OF THE ROOM. BOTH GAGE 1 AND 3 SHOW A PLATEAU BEFORE THE LOSS OF STRESS; HOWEVER, GAGE 2 MAY NOT BE AT A PLATEAU. GAGE 1 WAS DISCONTINUED FROM REMOTE RECORDING ON DAY 396, GAGE 2 ON DAY 364, AND GAGE 3 ALSO ON DAY 364. [COMPRESSION = 1.21:1] (DEM)

***** H_550 Location *****

Principal Station 090
Station 86.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_550-1	STR	T REM	H	5.73	0.85	86.89	92.25	-0.58	-0.66	-0.50	-0.58	SPCL.EN	06/28/84	58-0489#01	X-0.499Y+0.054Z+0.866
H_550-2	STR	T REM	H	5.73	1.16	86.89	90.60	-0.58	-0.65	-0.50	-0.57	SPCL.EN	06/28/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_550-3	STR	T REM	H	5.73	1.46	86.89	89.52	-0.58	-0.65	-0.50	-0.57	SPCL.EN	06/28/84	58-0489#01	X+0.499Y-0.054Z+0.866

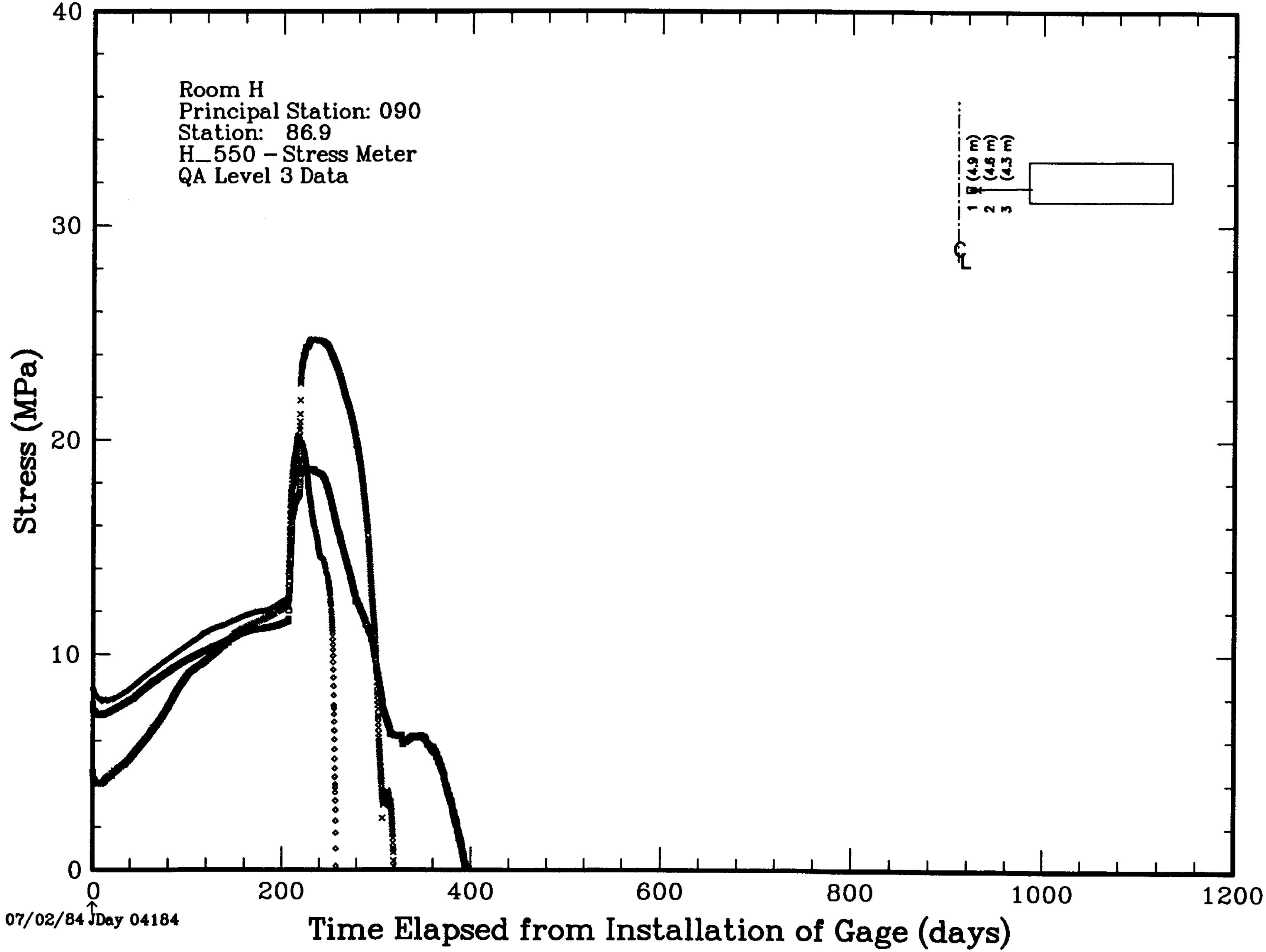

Figure 5.4.2b. SGS Stress Meters, H 550

Table 5.4.2c. SGS Stress Meters, H 551

Gage: H_551

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***** H_551 PI Comments *****

09/23/87 DLH:DEM [RANK = 10(1),10(2),10(3)] THIS UNIT IS ONE OF THOSE EMPLACED IN THE MILLAR MATERIAL PRIOR TO THE EXCAVATION OF ROOM H. THE GRADUAL INCREASE IN STRESS IS THE RESPONSE TO THE ROOM H ENTRY STRESS FIELD. EXCAVATION OF THE ROOM H CAUSED THE ABRUPT INCREASE IN THE STRESS RESPONSE OF THE GAGES, WITH EXCAVATION STARTING ON DAY 206 (JDAY 5024) AND ENDING ON DAY 237 (JDAY 5055). DECREASES IN THE STRESS OF GAGE 1 BEGAN ON DAY 251, GAGE 2 ON DAY 350, AND GAGE 3 ON ABOUT DAY 597. FOR GAGE 3 THE STRESS DETERIORATION STARTED SHORTLY AFTER THE TURN-ON OF THE HEATERS ON DAY 592 (JDAY 6044). THE DATA QUALITY OF THE UNIT IS OUTSTANDING, AND IS MARRED ONLY BY THE LOSS OF STRESS IN THE GAGES. [COMPRESSION 1.84:1] (DEM)

***** H_551 Location *****

Principal Station 090
Station 89.7

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_551-1	STR	T REM	H	5.71	3.27	89.69	90.11	-0.55	-0.56	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X-0.500Y+0.005Z+0.866
H_551-2	STR	T REM	H	5.71	3.58	89.69	90.00	-0.55	-0.56	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X 0.000Y 0.000Z+1.000
H_551-3	STR	T REM	H	5.71	3.88	89.69	89.96	-0.55	-0.55	-0.47	-0.48	SPCL.EN	06/29/84	58-0489#01	X+0.500Y-0.005Z+0.866

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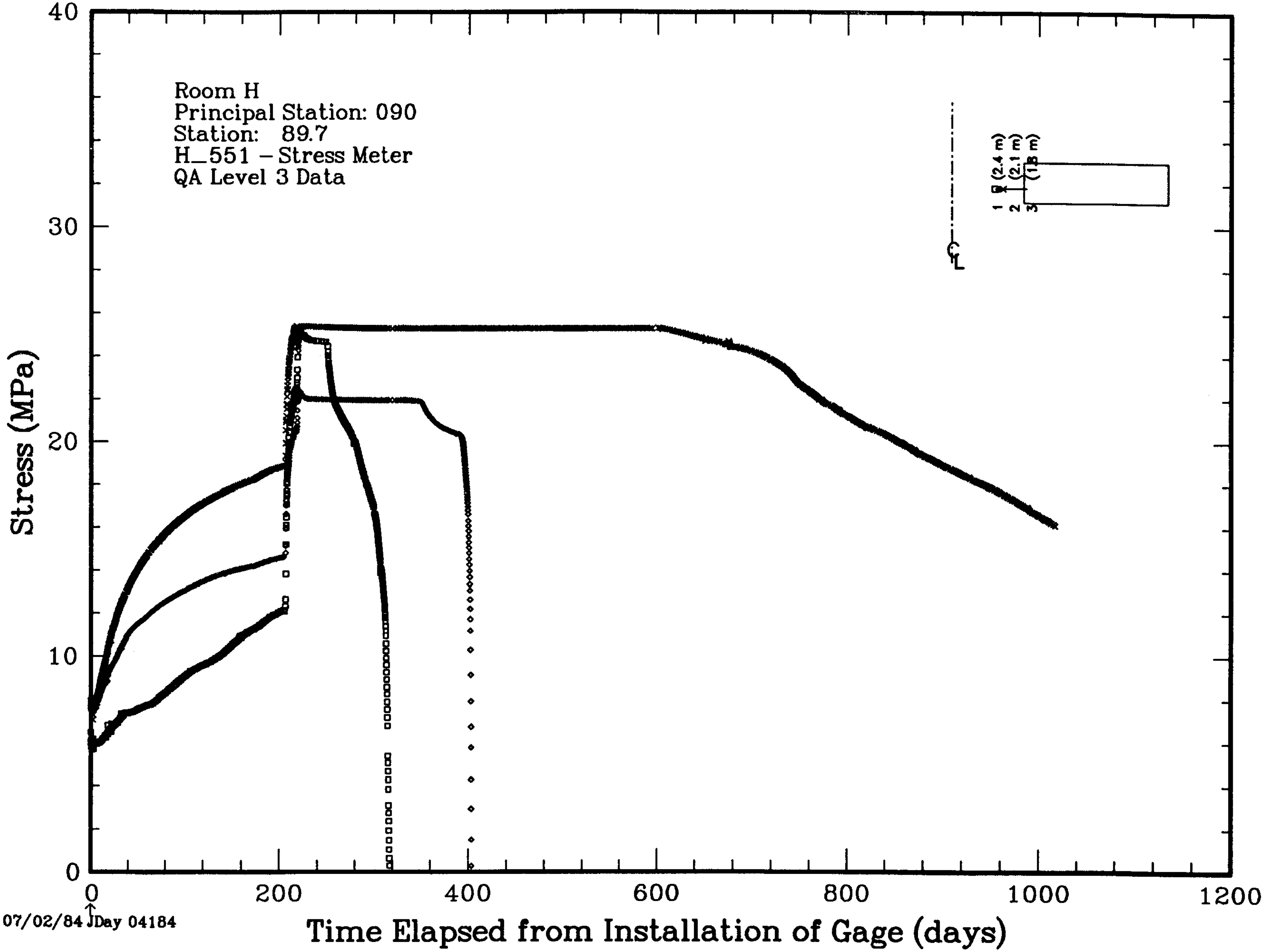

Figure 5.4.2c. SGS Stress Meters, H 551

the cartesian coordinate system are parallel to the T = 0^o and T = 90^o axes, respectively, of the cylindrical coordinate system defined for the room. Consequently, direction cosines reflect the true orientation of the sensing element with respect to both coordinate systems. In other words, the emplacement borehole direction is properly accounted for in the local cartesian system. Direction cosines are given in the individual gage location comments. In all cases except the BuMines CPC, the cosines define the direction of the force sensed by the element. For the CPC, the cosines define the direction of the unit normal of the sensing element. The difference in the CPC results from the CPC sensing the mean pressure in the plane normal to the gage axis. In this case, the sensing element direction is given logically by a unit normal which is colinear with the gage axis.

The accumulated placement errors during installation produce an uncertainty in the direction cosines of about +/- 5^o. Consequently, the detail shown for the individual direction cosines can be greatly simplified to give the results in Table 5.4.3. Examination of the table indicates clearly the systematic orientation of the stress sensing elements. This can be seen also in the schematic of BuMines gages in Figure 5.4.4 and of SGS gages in Figure 5.4.5. Each sensing element location and orientation is depicted through the use of a small symbol. (Note that unit H 520 was emplaced with the orientation of gages H 520-2 and H 520-3 reversed from the normal order). Thus, for the BuMines units, all H 5xx-3 (H 520-2) elements sense the tangential stress. All H 5xx-2 (H 520-3) elements sense various directions of stress starting with the vertical center stress and progressively changing to the horizontal stress

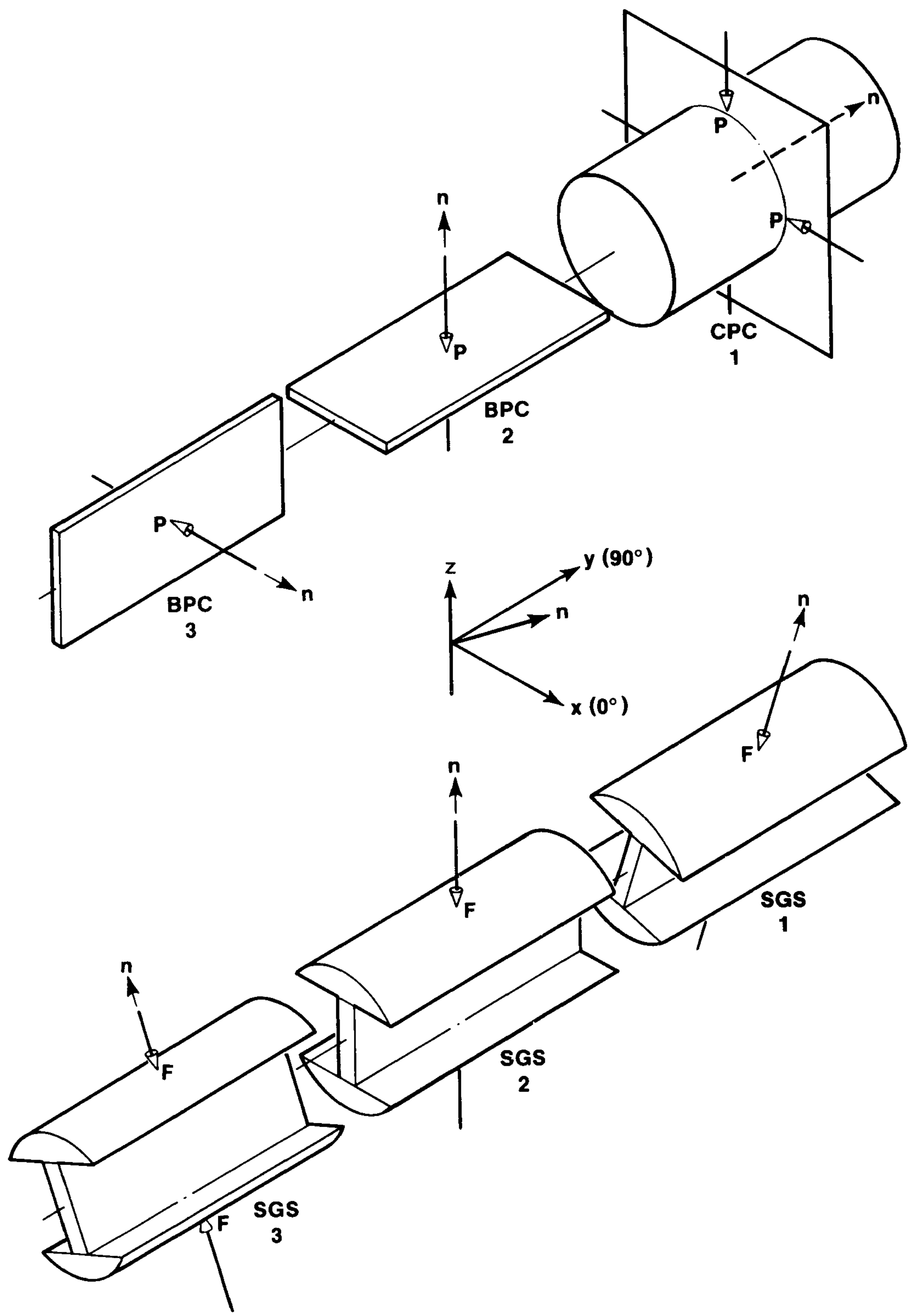

Figure 5.4.3. Specification of Stress Meter Sensing Directions.

Table 5.4.3 Simplified Direction Cosines of Unit Normals

Units\Gages	Direction Cosines -1 CPC			-2 BPC			-3 BPC		
	x	y	z	x	y	z	x	y	z
Vertical									
Up H 501,H 502	0.0	0.0	+1.0	+1.0	0.0	0.0	0.0	+1.0	0.0
Down H 504,H 505									
Up H 513,H 514									
Down H 516,H 517									
Horizontal									
Pil. H 519	+1.0	0.0	0.0	0.0	0.0	+1.0	0.0	+1.0	0.0
Rib H 523,H 524									
Pil. H 532,H 533									
Rib H 535,H 536									
Pil. H 520	+1.0	0.0	0.0	0.0	+1.0	0.0	0.0	0.0	+1.0
Diagonal(53.0°)									
Up H 537	+0.60	0.0	+0.80	+0.80	0.0	-0.60	0.0	+1.0	0.0
Down H 543	-0.60	0.0	+0.80	+0.80	0.0	+0.60	0.0	+1.0	0.0
Diagonal(30.0°)									
Up H 538	+0.87	0.0	-0.50	+0.50	0.0	+0.87	0.0	+1.0	0.0
Down H 544	+0.87	0.0	+0.50	-0.50	0.0	+0.87	0.0	+1.0	0.0
	-1 SGS(60)			-2 SGS(90)			-3 SGS(120)		
Horizontal									
Pil. H 549	-0.50	0.0	+0.87	0.0	0.0	+1.0	+0.50	0.0	+0.87
Pil. H 550									
Pil. H 551									

(Note: Reversal of gages H 520-2 and H 520-3 occurred during installation).

above the rooms. A similar change of sensing direction applies to all the H 5xx-3 elements. For the SGS gages which are only in the pillar, the sensing directions of the elements are uniform for all the units.

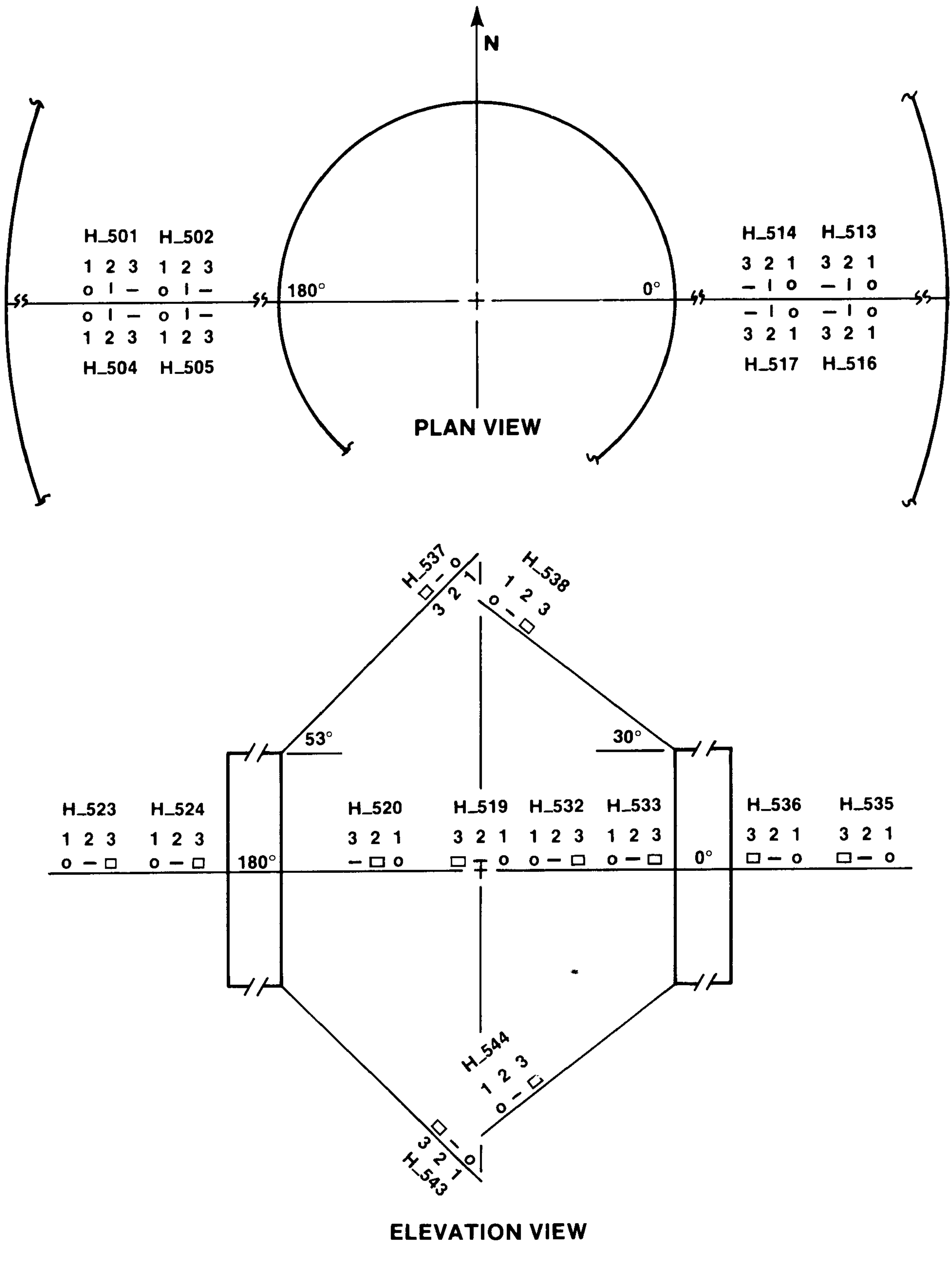

Figure 5.4.4. Orientations of BuMines Stress Meters.

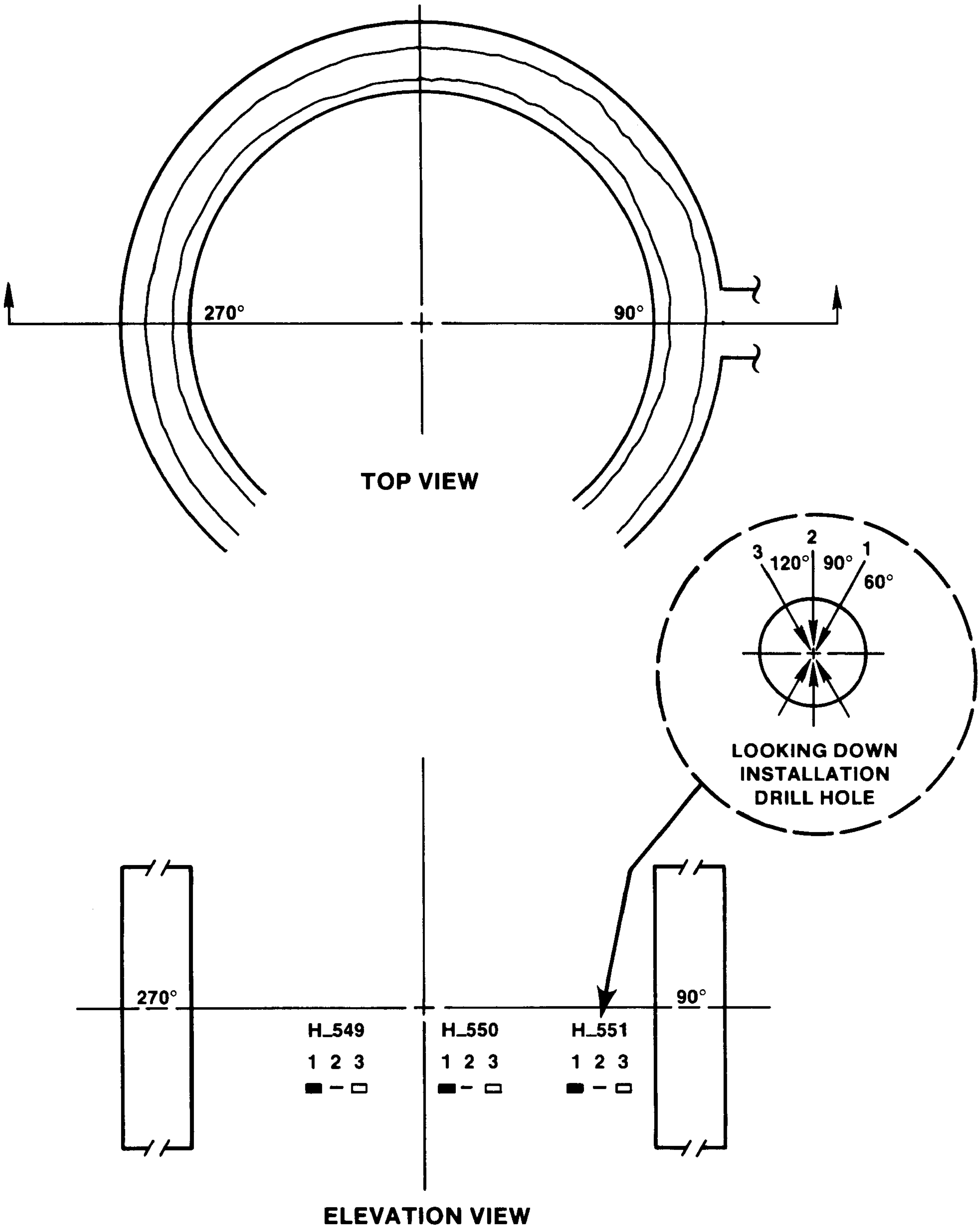

Figure 5.4.5. Orientations of SGS Stress Meters.

Details of stress data interpretation are given by Lu [22] for the BuMines gage and Cook [23] for the SGS gage. The SGS gage has also been analyzed by Morgan [24].

5.5 Temperature Measurements

The location of all thermocouples installed in Room H is given schematically in the guide of Table 5.5.1. It illustrates the relative gage positions at the principal stations of the room. In general, the gage numbers of collections of gages are in sequence. Thus, H 702 through H 705 are vertical emplacements with even-numbered units vertically up and odd-numbered units vertically down. H 708 through H 711 are horizontal emplacements, with even-numbered units in the pillar and odd-numbered units in the rib. Diagonal emplacement units H 714 through H 517, H 720 through H 623, and H 726 through H 729 are in the pillar. Diagonal emplacement units H 718, H 719, H 724, and H 725 are in the rib. The early emplacement unit H 701 from the room entry measures the far-field ground temperature.

Exact descriptions of individual gage locations are found in Tables 5.5.1a-z, and plots of the temperature data are found in Figures 5.5.1a-z.

Temperature measurements differ from mechanical measurements in that installation time has little, if any, meaning. Action occurs for a thermocouple only after heat application begins. As a result, the initial Julian date (Jdate) shown on the abscissa of the temperature plots is not the actual installation time but an arbitrary time of 200 days before heater turn on. Under ideal conditions, the temperature readings during the first 200 days recorded should be constant and the same value for all gages. However, this is not the case. Seasonal variation of the mean ventilation air temperature, activity in the room, and gage location cause the gages to vary as much as 1.0°C (1.8°F) as a function of time. The deepest gages show the least influence. This is also true for all gages in the pillar because the pillar was insulated from the ventilation air.

Temperature measurements in the pillar typically reflect any loss of heater power very strongly, especially gages near the pillar surface. Gage H 708-4 data (Figure 5.5.1f) indicate two major power outages of several days as abrupt temperature decreases at the time of power loss, followed by a more gradual return to temperature after restoration of power. Several other less-pronounced temperature perturbations, caused by power outages of short duration, can also be seen on the records of this gage. All gages are affected by the outages. However, as the data of H 708-1 (a deep gage) indicate, the perturbation is delayed and attenuated by movement into the salt.

An overview of the influence of heat on the temperature field around the room is best obtained from the reduced-size composite of Figure 2.3.2. It is clear qualitatively that the heat flow is almost entirely into the pillar. Gages in the pillar, or in root regions of the pillar, show the typically expected temperature gradients in time and distance caused by thermal conduction through the salt. This is not the case for gages remote from the pillar in the roof, floor, and rib of the room. The similarity of the temperature magnitudes and histories of the data for these gages implies that they are being heated by the same source, the radiative and convective heat transfer from the pillar heaters across the room itself. There appears to be little, if any, temperature gradient across the room.

Gages H 708-1 and H 712-1 (Figures 5.5.1f and 5.5.1j, positioned identically near the pillar center line, are in very good agreement and indicate, after 415 days of heating, a still slowly rising temperature, with a current value of 52^{o}C (125.6^{o}F). However, the pillar surface

Table 5.5.1. Thermocouple Units (Gages) Location Guide

Station	Direction		Relative Location: pillar	center	rib (entry)
H ST090	Vertical	roof			
	Diagonal				
	Diagonal				
	Horizontal	mid			H 701
	Diagonal				
	Diagonal				
	Vertical	floor			
H ST150	Vertical	roof		H 702	
	Diagonal	52.5,45.0	H 714		H 718
	Diagonal	30.0	H 715		
	Horizontal	mid	H 708		H 709
	Diagonal	30.0	H 717		
	Diagonal	52.5,45.0	H 716		H 719
	Vertical	floor		H 703	
H ST270	Vertical	roof		H 704	
	Diagonal	60.0,45.0	H 720		H 724
	Diagonal	45.0	H 721		
	Horizontal	mid	H 710		H 711
	Diagonal	45.0	H 723		
	Diagonal	60.0,45.0	H 722		H 725
	Vertical	floor		H 705	
H ST030	Vertical	roof			
	Diagonal	52.5	H 726		
	Diagonal	30.0	H 727		
	Horizontal	mid	H 712		
	Diagonal	30.0	H 729		
	Diagonal	52.5	H 728		
	Vertical	floor			

temperature is more difficult to determine. Sharp gradients and some differences in the placements of the near-surface thermocouples require more exact interpretations to obtain the actual surface temperature.

However, gage H 708-4 indicates a current near-surface (0.49 m or 1.6 ft beneath the surface) temperature is about 71°C (160°F).

In general, the temperature data presented are of high quality because it is the nature of thermocouples to give either correct temperatures or obviously incorrect scatter. For the most part, the data are very clean and appear predominantly correct. Incorrect scatter is easily eliminated from the records.

Table 5.5.1a. Thermocouples, H 701

Gage: H_701

****

***** H_701 PI Comments *****

08/16/87 DLH [RANK = 8(1)] MINOR AMOUNTS OF SCATTERED DATA FROM A RESISTANCE SHORT WERE DELETED; BETTER THAN 95% OF THE DATA ARE EXCELLENT. THE DATA DO HAVE AN UNACCOUNTED FOR RESIDUAL SCATTER OF ABOUT +/- 0.2 DEGREES; THIS IS ACCEPTABLE. [COMPRESSION 5.54:1] (DEM)

***** H_701 Location *****

Principal Station 090
Station 92.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_701-1	TC	P REM	H	46.00	49.00	92.14	110.25	0.09	-0.05	0.94	0.79	ARI	06/10/85	65-2785#09	

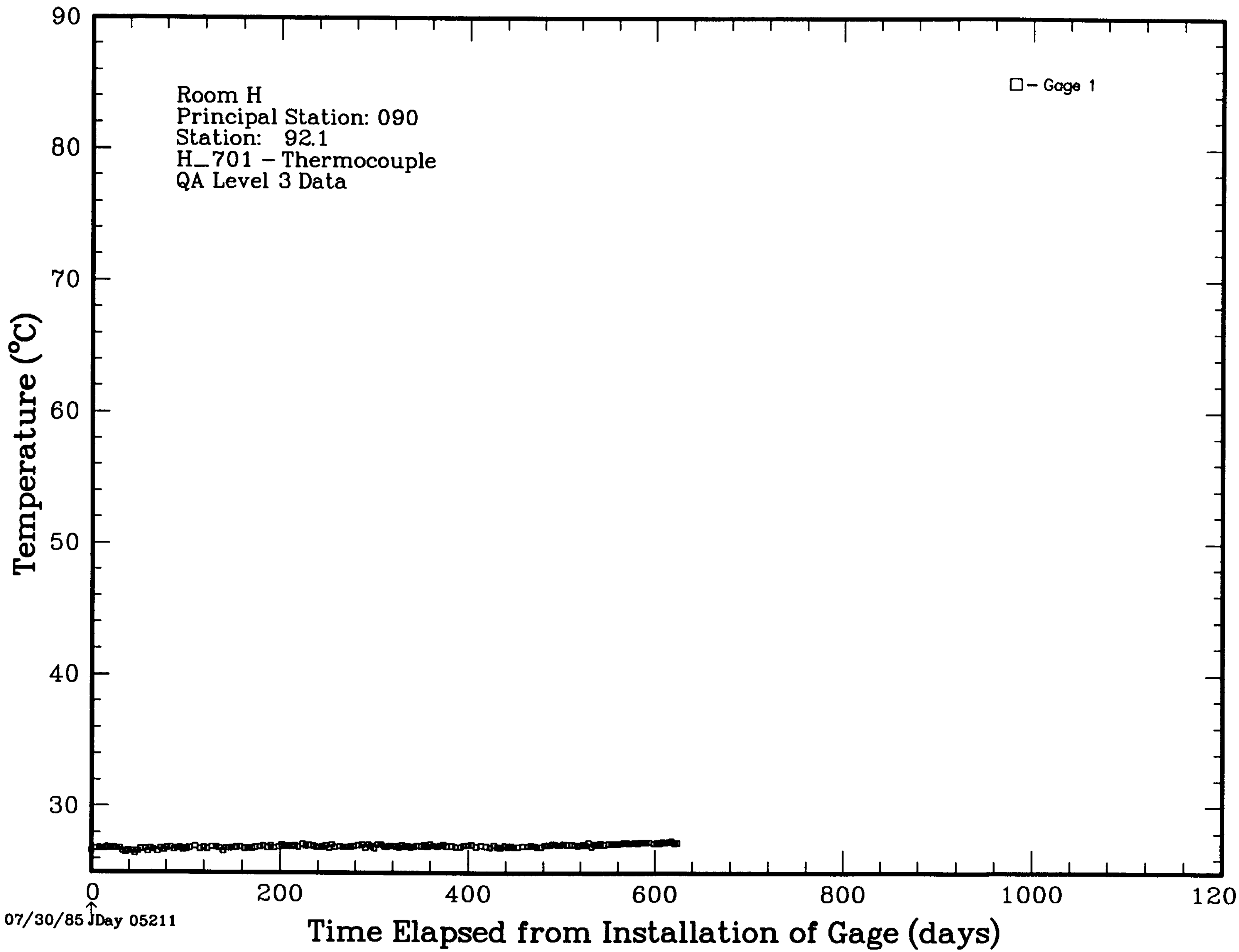

Figure 5.5.1a. Thermocouples, H 701

Table 5.5.1b. Thermocouples, H 702

Gage: H_702

****

***** H_702 PI Comments *****

08/16/87 DLH [RANK = 9(1),9(3),9(5)] THERE WAS SCATTER OF DATA BETWEEN DAY 206 AND 237 THAT WAS DELETED; HOWEVER, BETTER THAN 95% OF THE DATA WERE RETAINED. RESIDUAL SCATTER, WHILE NOT OBJECTIONABLE, LEAVES THE DATA QUALITY AS EXCEPTIONAL. [COMPRESSION = 9.64:1] (DEM)

***** H_702 Location *****

Principal Station 150
Station 149.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_702-1	TC	P REM	V	10.96	10.89	149.93	149.44	1.45	16.69	1.55	16.79	ARI	06/10/85	65-2785#02	
H_702-3	TC	P REM	V	10.96	10.94	149.93	149.86	1.45	6.33	1.55	6.43	ARI	06/10/85	65-2785#09	
H_702-5	TC	P REM	V	10.96	10.96	149.93	150.03	1.45	2.37	1.55	2.46	ARI	06/10/85	65-2785#17	

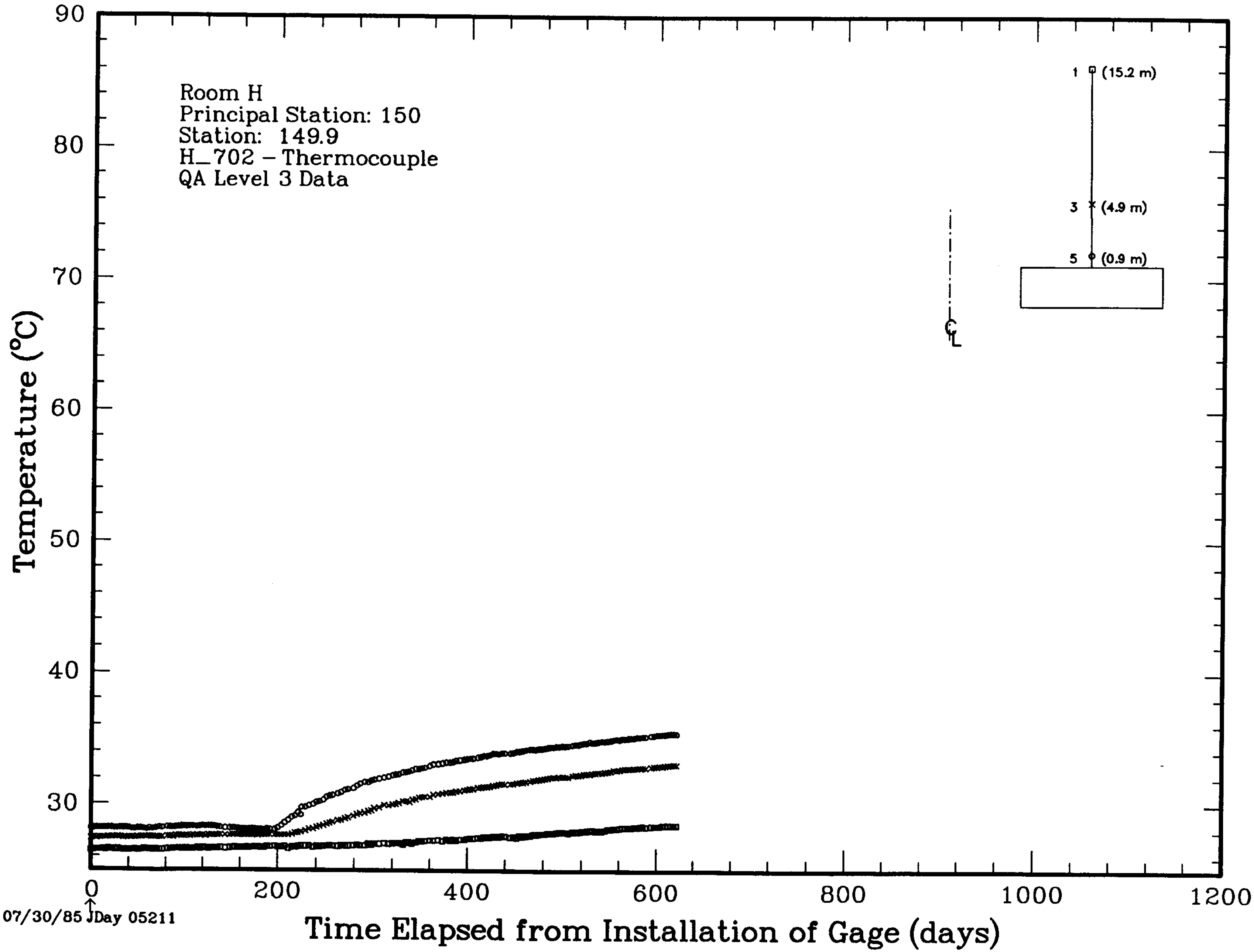

Figure 5.5.1b. Thermocouples, H 702

Table 5.5.1c. Thermocouples, H 703

Gage: H_703

****

***** H_703 PI Comments *****

08/16/87 DLH [RANK = 9(1),9(3),9(5)] SCATTER FROM A RESISTANCE SHORT WAS DELETED BETWEEN DAY 206 AND DAY 288. THIS WAS NOT SERIOUS AND BETTER THAN 95% OF THE DATA WERE RETAINED. RESIDUAL SCATTER OF DATA LEAVES A RANKING OF EXCEPTIONAL QUALITY. [COMPRESSION = 10.03:1] (DEM)

***** H_703 Location *****

Principal Station 150
Station 149.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_703-1	TC	P REM	V	10.96	10.94	149.93	149.31	-1.45	-16.69	-1.35	-16.59	ARI	06/10/85	65-2785#02	
H_703-3	TC	P REM	V	10.96	10.94	149.93	149.75	-1.45	-6.32	-1.35	-6.23	ARI	06/10/85	65-2785#09	
H_703-5	TC	P REM	V	10.96	10.93	149.93	149.93	-1.45	-2.36	-1.35	-2.26	ARI	06/10/85	6502785#17	

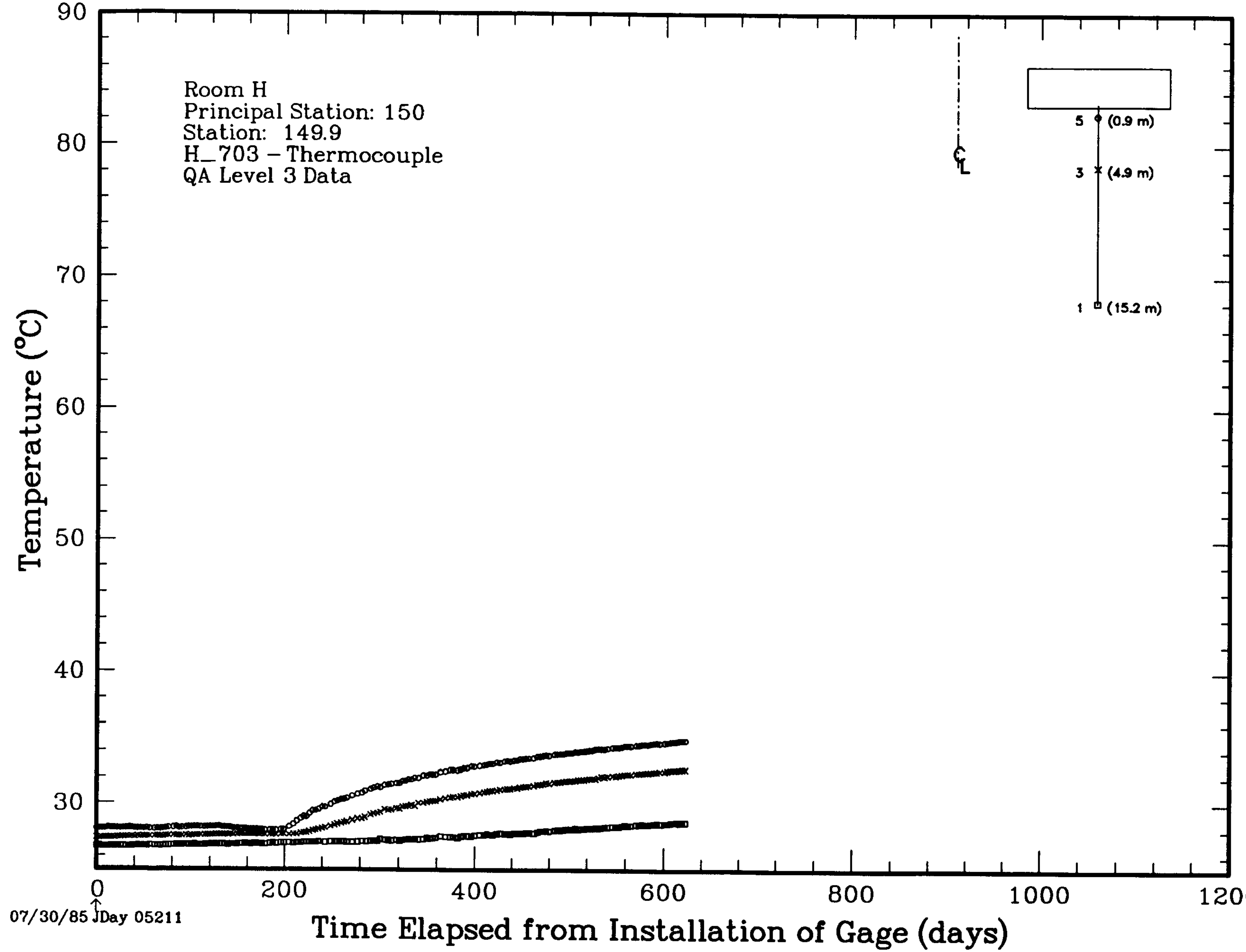

Figure 5.5.1c. Thermocouples, H 703

Table 5.5.1d. Thermocouples, H 704

Gage: H_704

****

***** H_704 PI Comments *****

08/16/87 DLH [RANK = 8(1),8(2),8(3),8(4),8(5)] THERE ARE SEVERAL TIMES WHERE THE DATA OF THIS UNIT SHOWED SCATTER FROM CONTACT RESISTANCE. THE MOST SEVERE WAS BETWEEN DAY 206 AND 260, WITH CONCENTRATIONS AT A FEW OTHER TIMES. EVEN WITH THIS SCATTER DELETION, DATA RETENTION IS BETTER THAN 95%. THE RESIDUAL DATA SCATTER IS SOMEWHAT LARGER, AS THE GRAPHS SHOW, WHICH RESULTS IN THE LOWER RANKING. EVEN WITH THE RESIDUAL SCATTER, THE DATA QUALITY IS EXCELLENT. [COMPRESSION = 4.23:1] (DEM)

***** H_704 Location *****

Principal Station 270
Station 272.9

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_704-1	TC	P REM	V	10.99	10.92	272.89	273.39	1.51	16.75	1.40	16.64	ARI	06/11/85	65-2785#02	
H_704-2	TC	P REM	V	10.99	10.94	272.89	273.19	1.51	10.65	1.40	10.55	ARI	06/11/85	65-2785#04	
H_704-3	TC	P REM	V	10.99	10.95	272.89	273.06	1.51	6.39	1.40	6.28	ARI	06/11/85	65-2785#09	
H_704-4	TC	P REM	V	10.99	10.96	272.89	272.97	1.51	3.34	1.40	3.23	ARI	06/11/85	65-2785#16	
H_704-5	TC	P REM	V	10.99	10.96	272.89	272.93	1.51	2.42	1.40	2.32	ARI	06/11/85	65-2785#17	

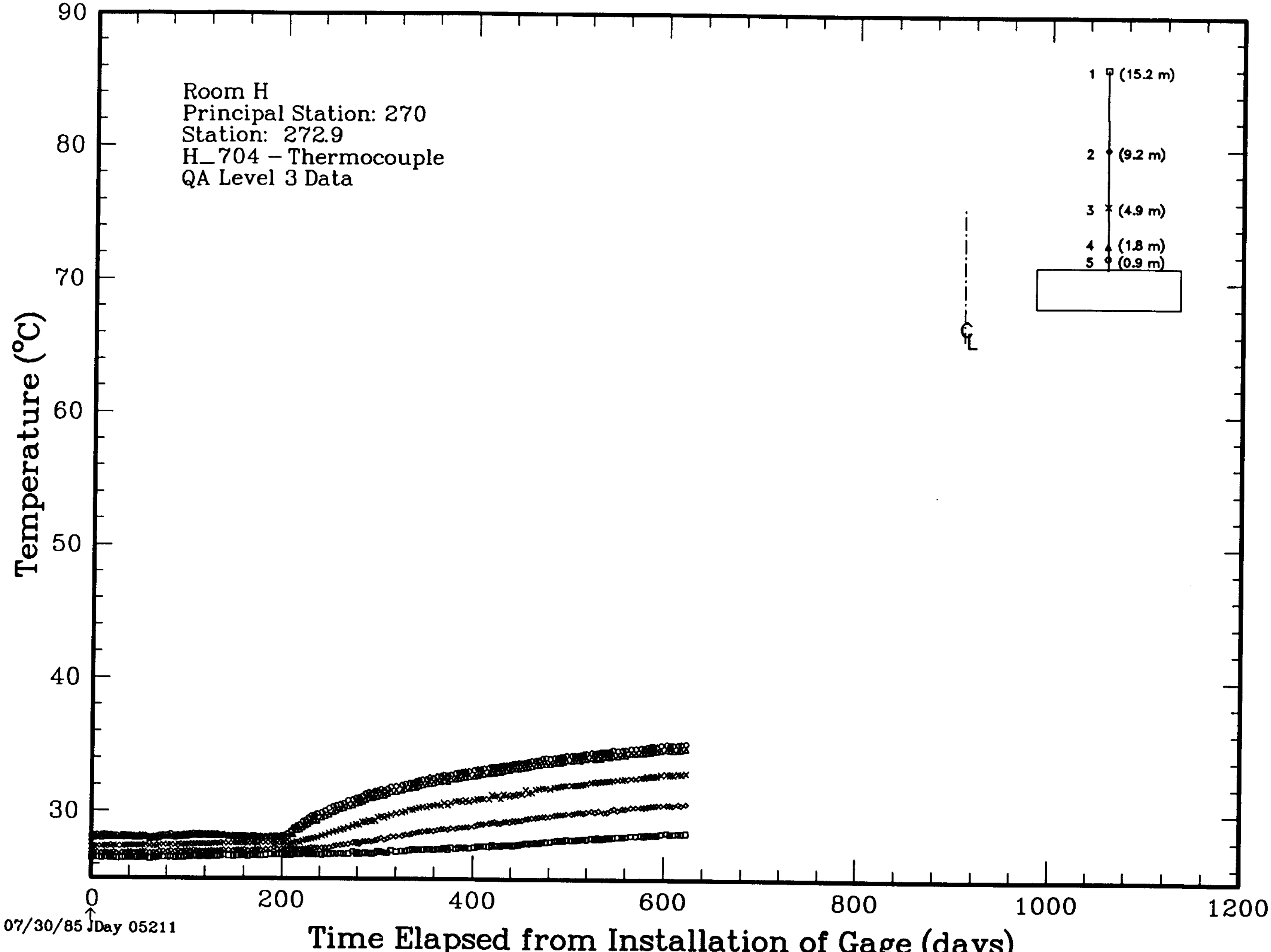

Figure 5.5.1d. Thermocouples, H 704

Table 5.5.1e. Thermocouples, H 705

Gage: H_705

****

***** H_705 PI Comments *****

08/16/87 DLH [RANK = 8(1),8(2),8(3),8(4),8(5)] THE UNIT SUFFERED FROM SCATTER OF CONTACT RESISTANCE SHORTS; AGAIN, THE MOST SEVERE OCCUR BETWEEN DAY 206 AND 258. BETTER THAN 95% RETENTION OF DATA STILL APPLIES, HOWEVER. THE SOMEWHAT GREATER RESIDUAL SCATTER REDUCES THE QUALITY, WHICH EVEN THEN REMAINS AT AN EXCELLENT LEVEL. [COMPRESSION 5.97:1] (DEM)

***** H_705 Location *****

Principal Station 270
Station 273.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_705-1	TC	P REM	V	11.00	10.98	272.97	273.20	-1.51	-16.75	-1.62	-16.86	ARI	06/11/85	65-2785#02	
H_705-2	TC	P REM	V	11.00	10.98	272.97	273.12	-1.51	-10.66	-1.62	-10.77	ARI	06/11/85	65-2785#04	
H_705-3	TC	P REM	V	11.00	10.98	272.97	273.06	-1.51	-6.39	-1.62	-6.50	ARI	06/11/85	65-2785#09	
H_705-4	TC	P REM	V	11.00	10.97	272.97	273.01	-1.51	-3.34	-1.62	-3.45	ARI	06/11/85	65-2785#16	
H_705-5	TC	P REM	V	11.00	10.97	272.97	272.99	-1.51	-2.43	-1.62	-2.54	ARI	06/11/85	65-2785#17	

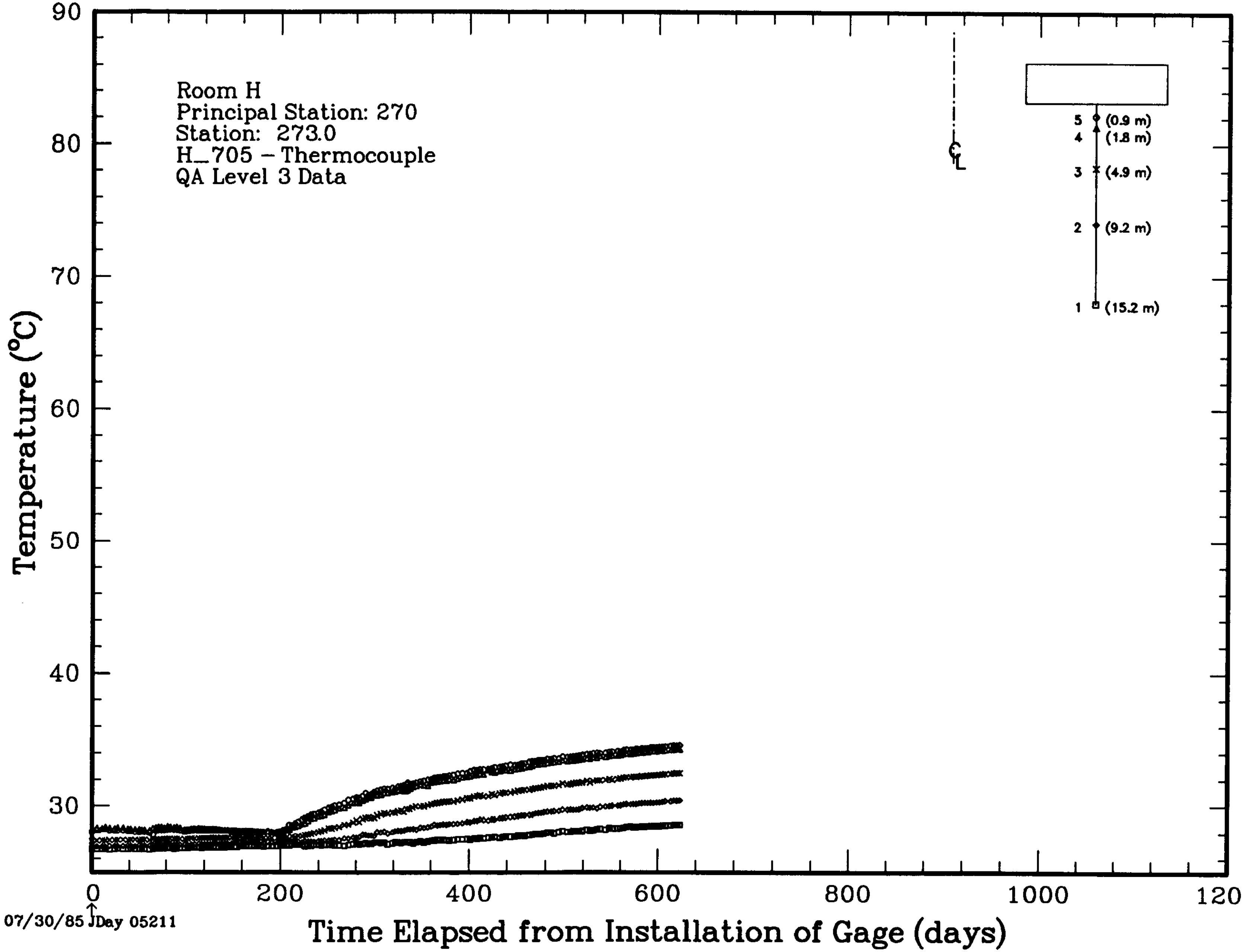

Figure 5.5.1e. Thermocouples, H 705

Table 5.5.1f. Thermocouples, H 708

Gage: H_708

****

***** H_708 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),9(3),9(4)] ALL THE DATA OF THIS UNIT IS EXCEPTIONAL, WITH ONLY A FEW MINOR DELETIONS OF SPURIOUS POINTS REQUIRED. [COMPRESSION = 3.46:1] (DEM)

***** H_708 Location *****

Principal Station 150
Station 150.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_708-1	TC	P REM	H	5.59	1.01	150.01	150.44	-0.01	-0.06	0.09	0.04	ARI	06/12/85	65-2785#13	
H_708-2	TC	P REM	H	5.59	2.54	150.01	150.11	-0.01	-0.05	0.09	0.04	ARI	06/12/85	65-2785#16	
H_708-3	TC	P REM	H	5.59	3.76	150.01	150.04	-0.01	-0.04	0.09	0.05	ARI	06/12/85	65-2785#17	
H_708-4	TC	P REM	H	5.59	4.98	150.01	150.01	-0.01	-0.04	0.09	0.06	ARI	06/12/85	65-2785#17	

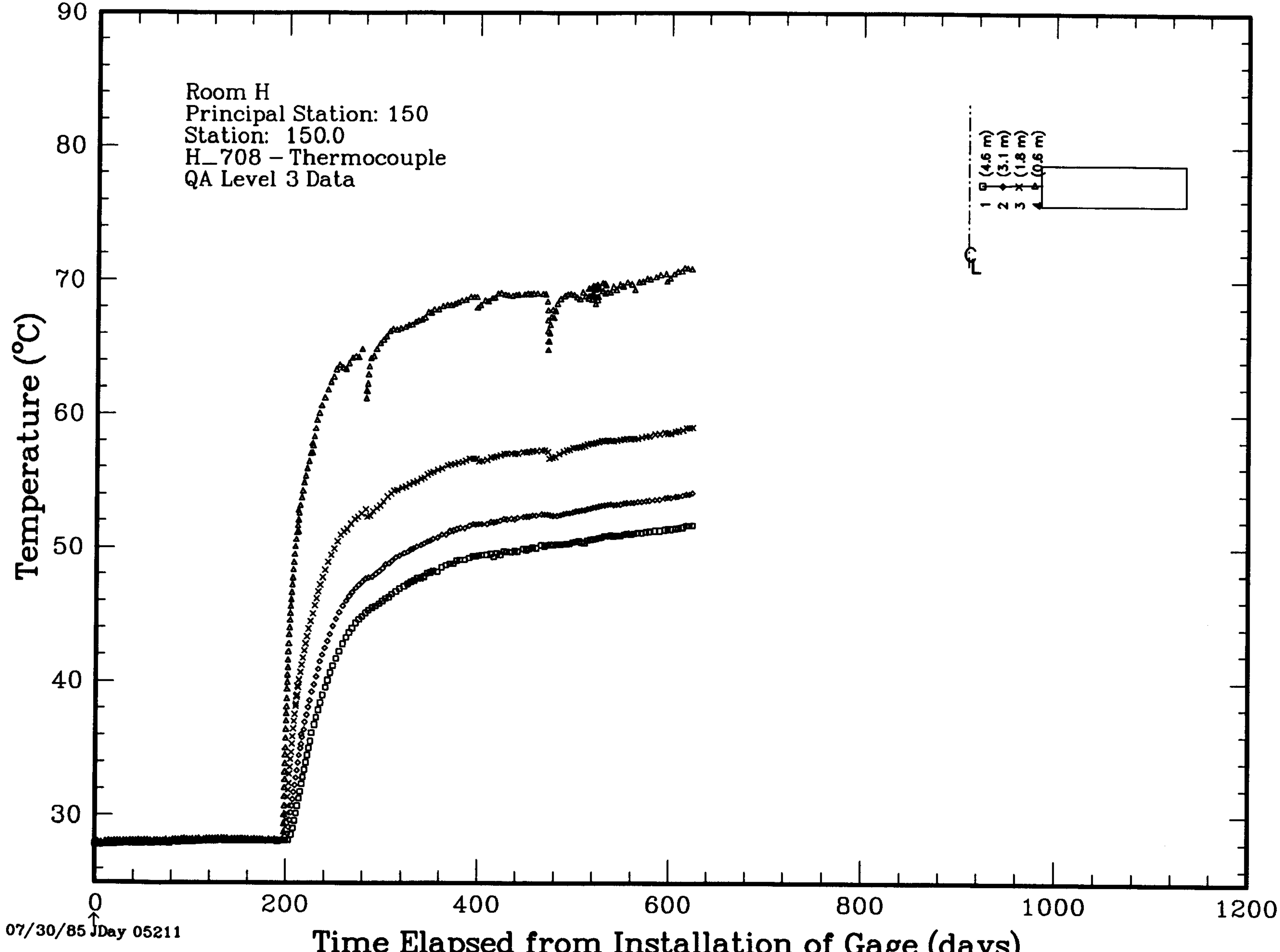

Figure 5.5.1f. Thermocouples, H 708

Table 5.5.1g. Thermocouples, H 709

Gage: H_709

****

***** H_709 PI Comments *****

08/17/87 DLH [RANK = 8(1),9(3),9(5)] GAGE 1 HAS A LITTLE HIGHER RESIDUAL SCATTER, WHICH ACCOUNTS FOR THE LOWER QUALITY. IT IS STILL PERFECTLY ADEQUATE FOR USE. GAGES 3 AND 5 HAVE EXCEPTIONAL QUALITY DATA. MINOR AMOUNTS OF RESISTANCE SCATTER HAS BEEN DELETED FROM ALL GAGE RECORDS. [COMPRESSION = 7.07:1] (DEM)

***** H_709 Location *****

Principal Station 150
Station 149.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_709-1	TC	P REM	H	16.36	31.60	149.94	149.88	0.00	-0.06	0.09	0.04	ARI	06/10/85	65-2785#02	
H_709-3	TC	P REM	H	16.36	21.24	149.94	149.91	0.00	-0.04	0.09	0.05	ARI	06/10/85	65-2785#09	
H_709-5	TC	P REM	H	16.36	17.28	149.94	149.94	0.00	-0.03	0.09	0.06	ARI	06/10/85	65-2785#17	

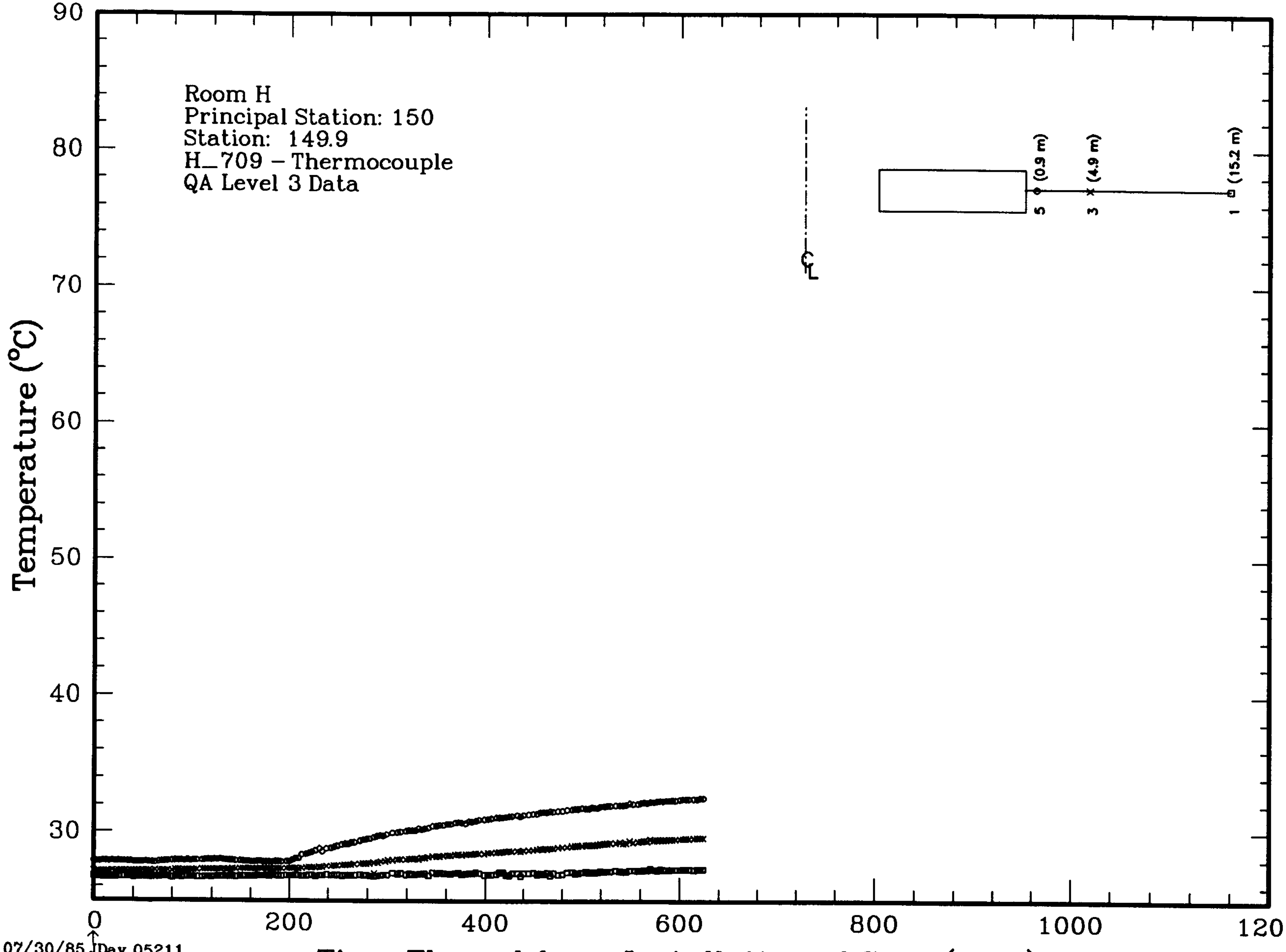

Figure 5.5.1g. Thermocouples, H 709

Table 5.5.1h. Thermocouples, H 710

Gage: H_710

****

***** H_710 PI Comments *****

08/17/87 DLH [RANK = 6(2),9(3),9(4)] GAGE 1 NEVER EXISTED. GAGE 2 HAS TWO REGIONS OF SCATTER DUE TO RESISTANCE SHORT WHICH HAVE BEEN DELETED. THE DATA OF GAGES 3 AND 4 ARE OF EXCEPTIONAL QUALITY. [COMPRESSION 2.52:1] (DEM)

***** H_710 Location *****

Principal Station 270
Station 270.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_710-2	TC	P REM	H	5.59	2.54	270.03	270.07	-0.05	-0.07	-0.16	-0.18	ARI	06/12/85	65-2785#13	
H_710-3	TC	P REM	H	5.59	3.76	270.03	270.05	-0.05	-0.07	-0.16	-0.18	ARI	06/12/85	65-2785#16	
H_710-4	TC	P REM	H	5.59	4.68	270.03	270.04	-0.05	-0.07	-0.16	-0.18	ARI	06/12/85	65-2785#17	

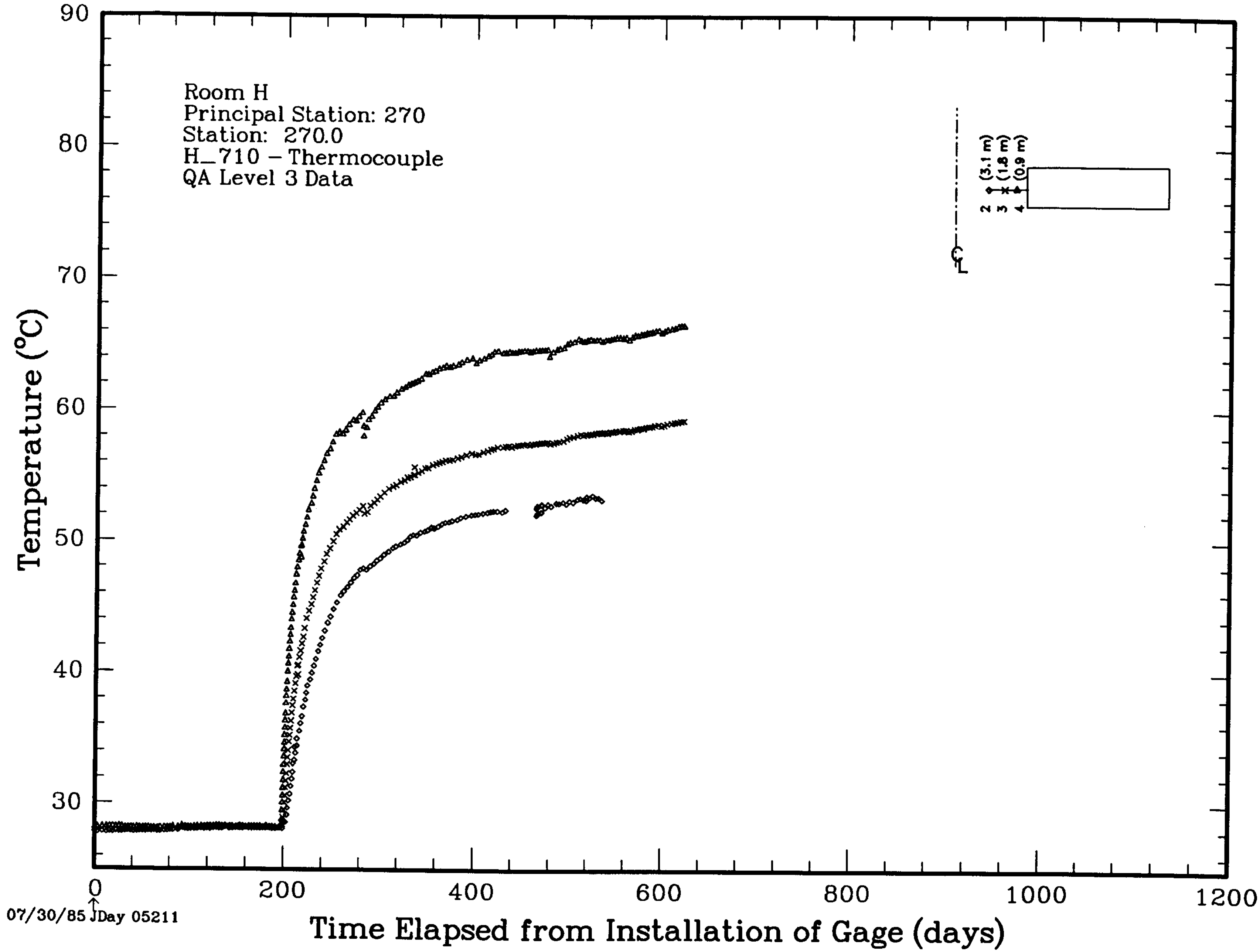

Figure 5.5.1h. Thermocouples, H 710

Table 5.5.1i. Thermocouples, H 711

Gage: H_711

****

***** H_711 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4),8(5)] WHILE THE DATA OF THIS UNIT ARE ALL EXCEPTIONAL, THE LOWER RANKING IS THE RESULT OF A SOMEWHAT HIGHER AMOUNT OF MINOR RESISTANCE SCATTER AND ALSO A HIGHER RESIDUAL SCATTER. [COMPRESSION = 7.10:1] (DEM)

***** H_711 Location *****

Principal Station 270
Station 270.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_711-1	TC	P REM	H	16.42	31.66	269.98	269.96	-0.05	-0.04	-0.16	-0.15	ARI	06/11/85	65-2785#02	
H_711-2	TC	P REM	H	16.42	25.56	269.98	269.97	-0.05	-0.06	-0.16	-0.17	ARI	06/11/85	65-2785#04	
H_711-3	TC	P REM	H	16.42	21.29	269.98	269.97	-0.05	-0.07	-0.16	-0.18	ARI	06/11/85	65-2785#09	
H_711-4	TC	P REM	H	16.42	18.25	269.98	269.97	-0.05	-0.08	-0.16	-0.19	ARI	06/11/85	65-2785#16	
H_711-5	TC	P REM	H	16.42	17.33	269.98	269.98	-0.05	-0.08	-0.16	-0.19	ARI	06/11/85	65-2785#17	

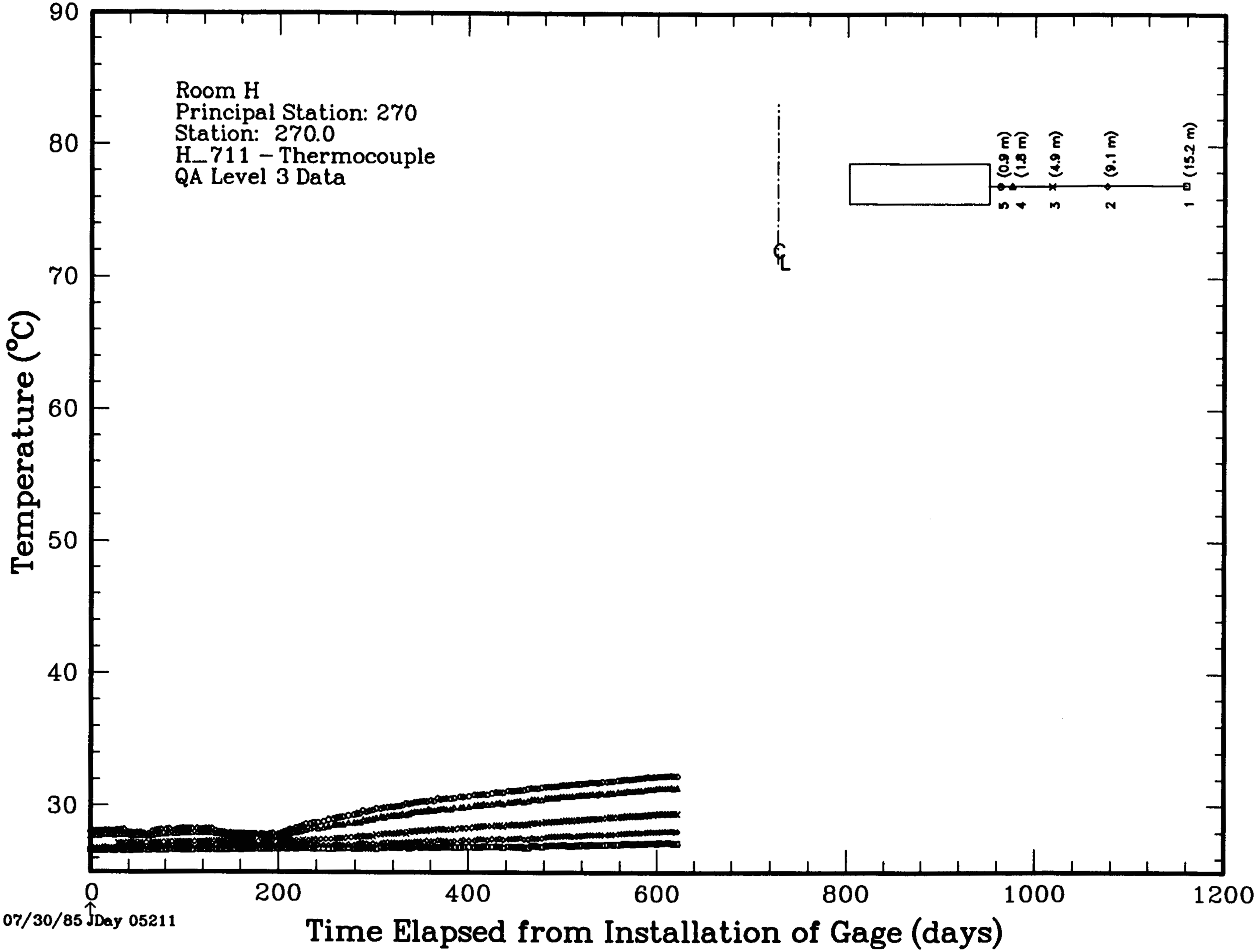

Figure 5.5.1i. Thermocouples, H 711

Table 5.5.1j. Thermocouples, H 712

Gage: H_712

****

***** H_712 PI Comments *****

08/17/87 DLH [RANK = 8(1),9(2),9(3),9(4)] THE DATA OF THIS UNIT ARE ALL EXCEPTIONAL. THE EARLY DATA, PRIOR TO TURN ON OF THE HEATERS, OF GAGE 1 WAS BADLY SCATTERED AND THEREFORE DELETED; BUT THIS DOES NOT AFFECT THE IMPORTANT TEMPERATURE DATA NOR THE QUALITY OF THE IMPORTANT DATA. THE TEMPERATURE DROPS AND OTHER VARIATIONS OF GAGES 3 AND 4 ARE REAL, BEING PRODUCED BY POWER OUTAGES AND MAINTENANCE. [COMPRESSION 3.69:1] (DEM)

***** H_712 Location *****

Principal Station 030
Station 29.7

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_712-1	TC	P REM	H	5.53	0.94	29.73	27.97	0.00	-0.02	0.04	0.03	ARI	06/12/85	65-2785#09	
H_712-2	TC	P REM	H	5.53	2.47	29.73	29.31	0.00	-0.02	0.04	0.02	ARI	06/12/85	65-2785#13	
H_712-3	TC	P REM	H	5.53	3.69	29.73	29.59	0.00	-0.02	0.04	0.02	ARI	06/12/85	65-2785#16	
H_712-4	TC	P REM	H	5.53	4.92	29.73	29.69	0.00	-0.03	0.04	0.02	ARI	06/12/85	65-2785#18	

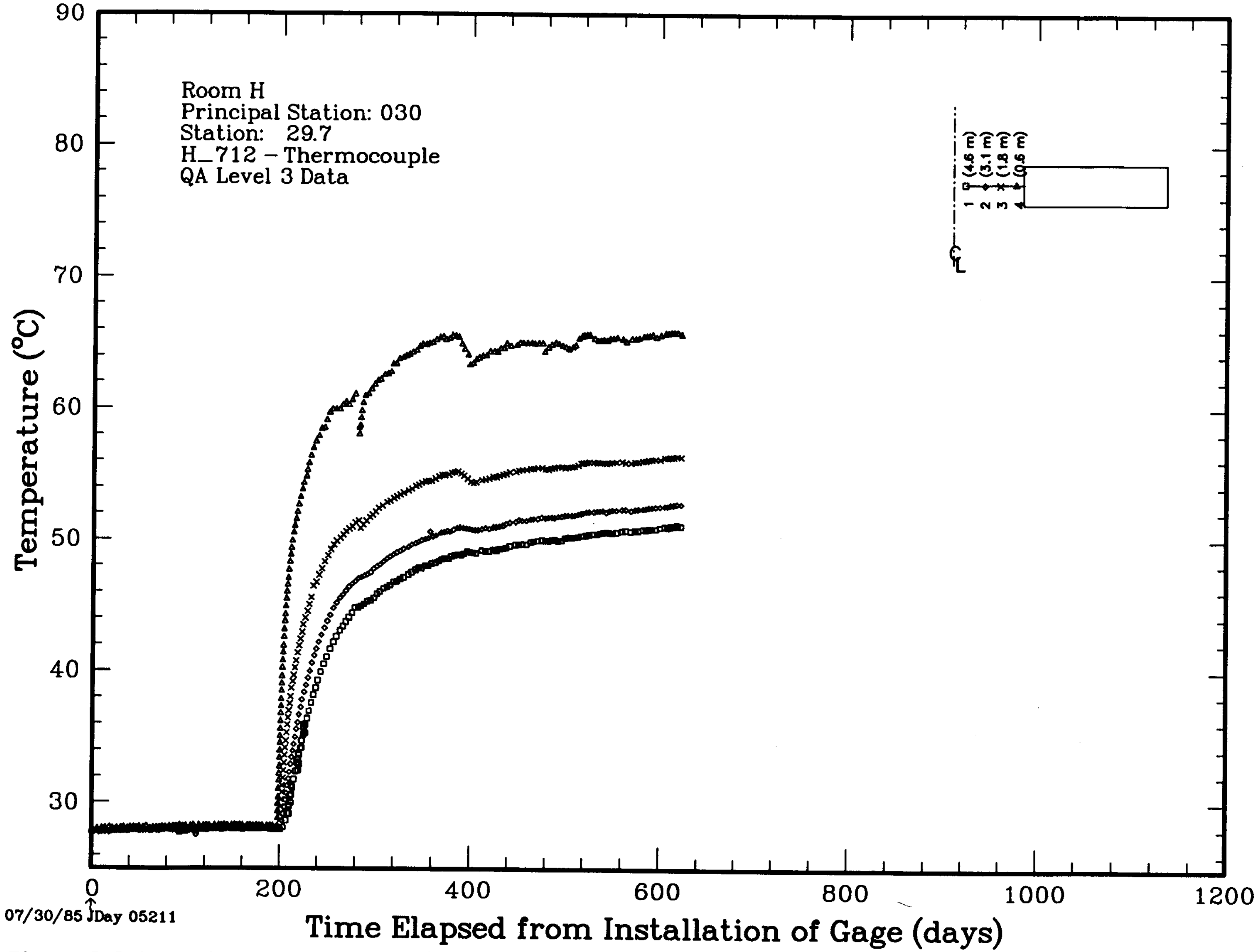

Figure 5.5.1j. Thermocouples, H 712

Table 5.5.1k. Thermocouples, H 714

Gage: H_714

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***** H_714 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),9(3),9(4)] ALL DATA ARE EXCEPTIONAL FOR THIS UNIT, WITH ONLY MINOR RESISTANCE SCATTER REMOVED. [COMPRESSION = 7.28:1] (DEM)

***** H_714 Location *****

Principal Station 150
Station 150.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_714-1	TC	P REM	D	5.96	0.88	150.00	147.32	1.41	8.05	1.51	8.15	ARI	06/12/85	65-2785#04	
H_714-2	TC	P REM	D	5.96	2.41	150.00	149.32	1.41	6.05	1.51	6.15	ARI	06/12/85	65-2785#07	
H_714-3	TC	P REM	D	5.96	3.65	150.00	149.75	1.41	4.44	1.51	4.54	ARI	06/12/85	65-2785#11	
H_714-4	TC	P REM	D	5.96	4.87	150.00	149.92	1.41	2.78	1.51	2.88	ARI	06/12/85	65-2785#16	

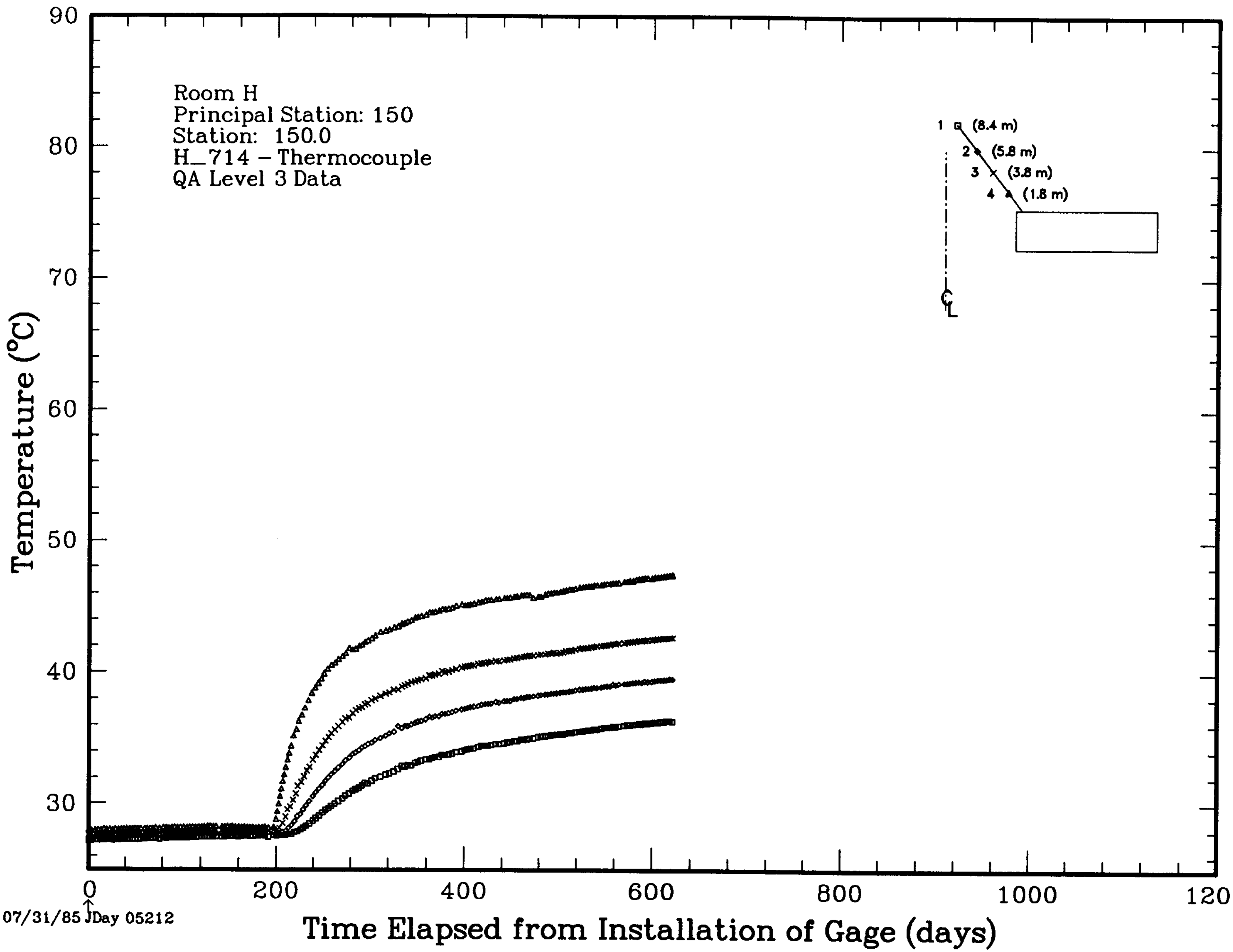

Figure 5.5.1k. Thermocouples, H 714

Table 5.5.11. Thermocouples, H 715

| Gage: H_715 |

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***** H_715 PI Comments *****

08/17/87 DLH [RANK = 9(1),6(2),9(3),9(4)] GAGE 2 HAS TWO NOISY SEGMENTS BETWEEN DAYS 371 AND 418 AND DAYS 427 AND 589 WHICH WERE DELETED. THIS LOWERS THE QUALITY OF THE GAGE ACCORDINGLY. THE REMAINING DATA, AS FOR THE OTHER GAGES, ARE OF EXCEPTIONAL QUALITY. MINOR SCATTER WAS REMOVED FORM ALL GAGES. [COMPRESSION = 2.59:1] (DEM)

***** H_715 Location *****

Principal Station 150
Station 150.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_715-1	TC	P REM	D	5.71	1.11	150.05	149.35	1.32	3.92	1.41	4.01	ARI	06/12/85	65-2785#07	
H_715-2	TC	P REM	D	5.71	2.63	150.05	149.87	1.32	3.05	1.41	3.15	ARI	06/12/85	65-2785#10	
H_715-3	TC	P REM	D	5.71	3.86	150.05	149.98	1.32	2.35	1.41	2.45	ARI	06/12/85	65-2785#13	
H_715-4	TC	P REM	D	5.71	5.08	150.05	150.02	1.32	1.66	1.41	1.76	ARI	06/12/85	65-2785#17	

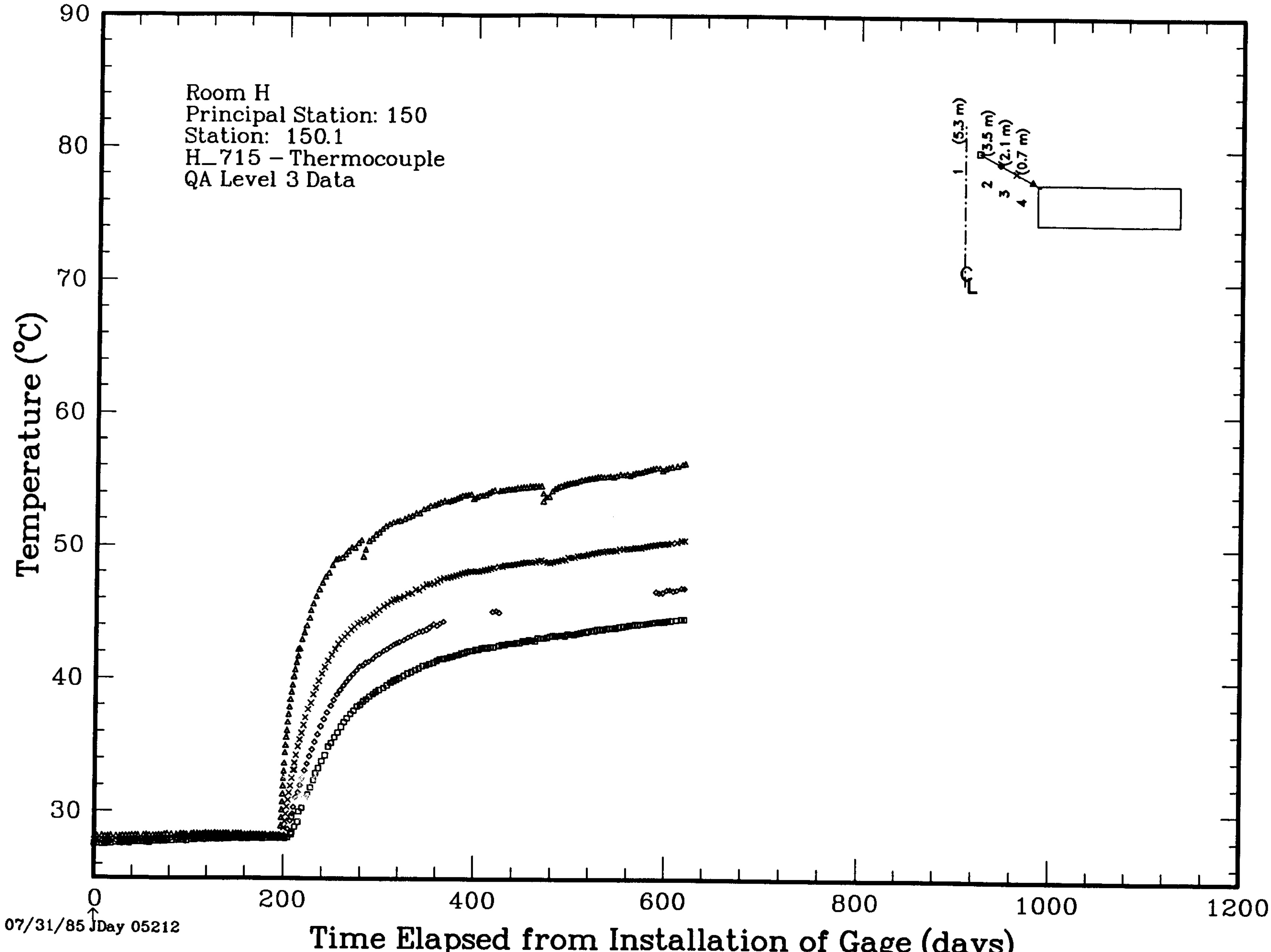

Figure 5.5.11. Thermocouples, H 715

Table 5.5.1m. Thermocouples, H 716

Gage: H_716

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***** H_716 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),9(3),9(4)] ALL THE DATA ARE EXCEPTIONAL FOR THIS UNIT, WITH ONLY MINOR RESISTANCE SCATTER DELETED. RESISUAL SCATTER IS VERY SMALL. [COMPRESSION = 7.44:1] (DEM)

***** H_716 Location *****

Principal Station 150
Station 149.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_716-1	TC	P REM	D	6.04	0.99	149.95	149.72	-1.47	-8.13	-1.37	-8.03	ARI	06/12/85	65-2785#04	
H_716-2	TC	P REM	D	6.04	2.51	149.95	149.88	-1.47	-6.12	-1.37	-6.03	ARI	06/12/85	65-2785#07	
H_716-3	TC	P REM	D	6.04	3.73	149.95	149.94	-1.47	-4.50	-1.37	-4.40	ARI	06/12/85	65-2785#11	
H_716-4	TC	P REM	D	6.04	4.95	149.95	149.93	-1.47	-2.84	-1.37	-2.75	ARI	06/12/85	65-2785#16	

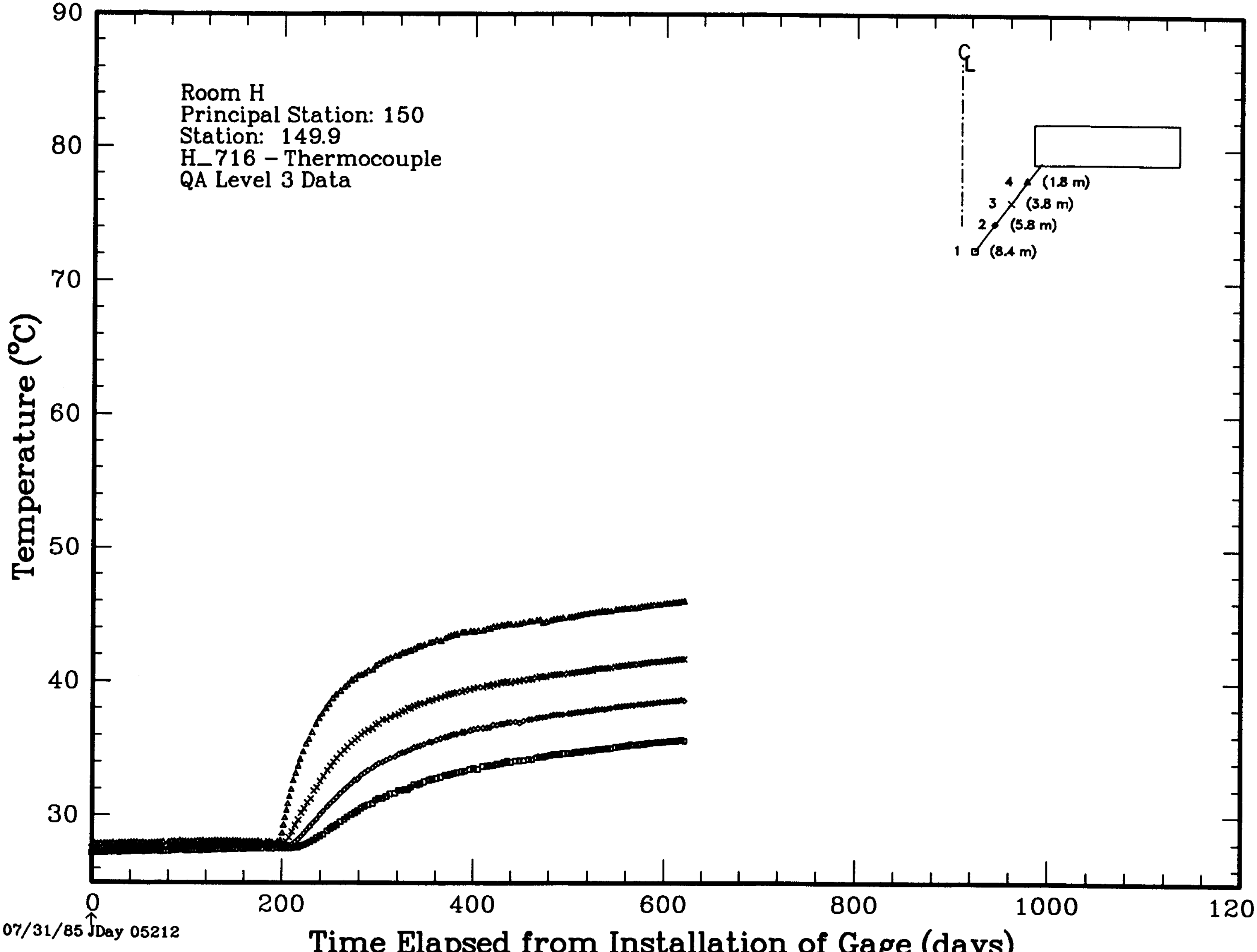

Figure 5.5.1m. Thermocouples, H 716

Table 5.5.1n. Thermocouples, H 717

Gage: H_717

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***** H_717 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),9(3),9(4)] ALL THE DATA OF THIS UNIT ARE EXCEPTIONAL. MINOR DATA SCATTER HAS BEEN REMOVED. [COMPRESSION = 6.15:1] (DEM)

***** H_717 Location *****

Principal Station 150
Station 150.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_717-1	TC	P REM	D	5.75	1.19	149.99	150.34	-1.41	-4.05	-1.31	-3.95	ARI	06/12/85	65-2785#07	
H_717-2	TC	P REM	D	5.75	2.70	149.99	150.11	-1.41	-3.16	-1.31	-3.07	ARI	06/12/85	65-2785#10	
H_717-3	TC	P REM	D	5.75	3.92	149.99	150.01	-1.41	-2.45	-1.31	-2.35	ARI	06/12/85	65-2785#13	
H_717-4	TC	P REM	D	5.75	5.14	149.99	150.00	-1.41	-1.75	-1.31	-1.65	ARI	06/12/85	65-2785#17	

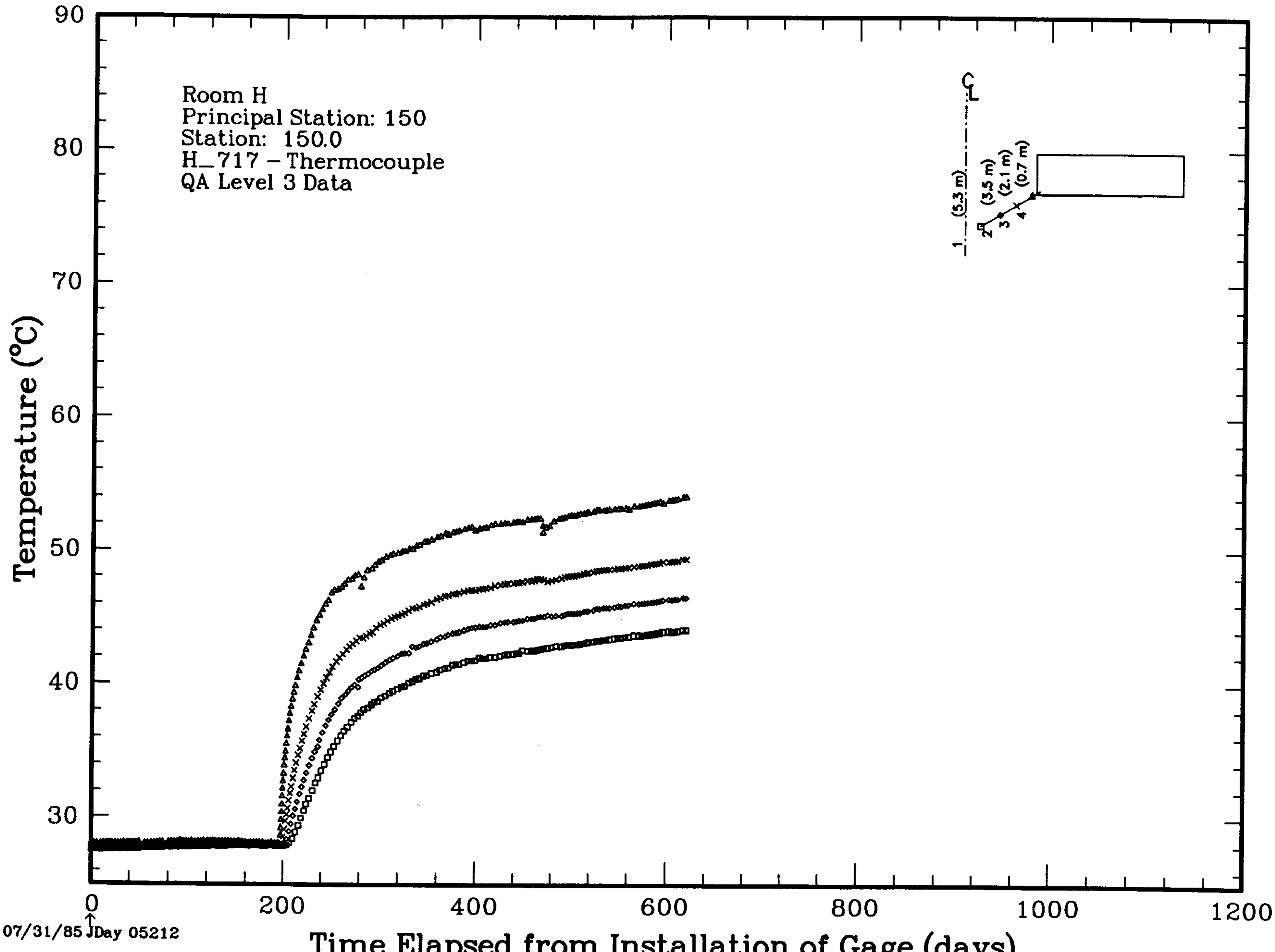

Figure 5.5.1n. Thermocouples, H 717

Table 5.5.1o. Thermocouples, H 718

Gage: H_718

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***** H_718 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(3),8(5)] THE DATA QUALITY IS EXCELLENT. FOR UNKNOWN REASONS THE RESIDUAL SCATTER IS SOMEWHAT HIGHER FOR THIS UNIT, WHICH ACCOUNTS FOR THE LOWER QUALITY RANKING. MINOR DELETIONS OF RESISTANCE SCATTER WERE MADE ON ALL GAGES. [COMPRESSION = 9.28:1] (DEM)

***** H_718 Location *****

Principal Station 150
Station 149.8

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_718-1	TC	P REM	D	16.17	26.94	149.84	149.61	1.29	12.09	1.39	12.18	ARI	06/10/85	65-2785#02	
H_718-3	TC	P REM	D	16.17	19.60	149.84	149.74	1.29	4.76	1.39	4.85	ARI	06/10/85	65-2785#08	
H_718-5	TC	P REM	D	16.17	16.80	149.84	149.83	1.29	1.95	1.39	2.05	ARI	06/10/85	65-2786#16	

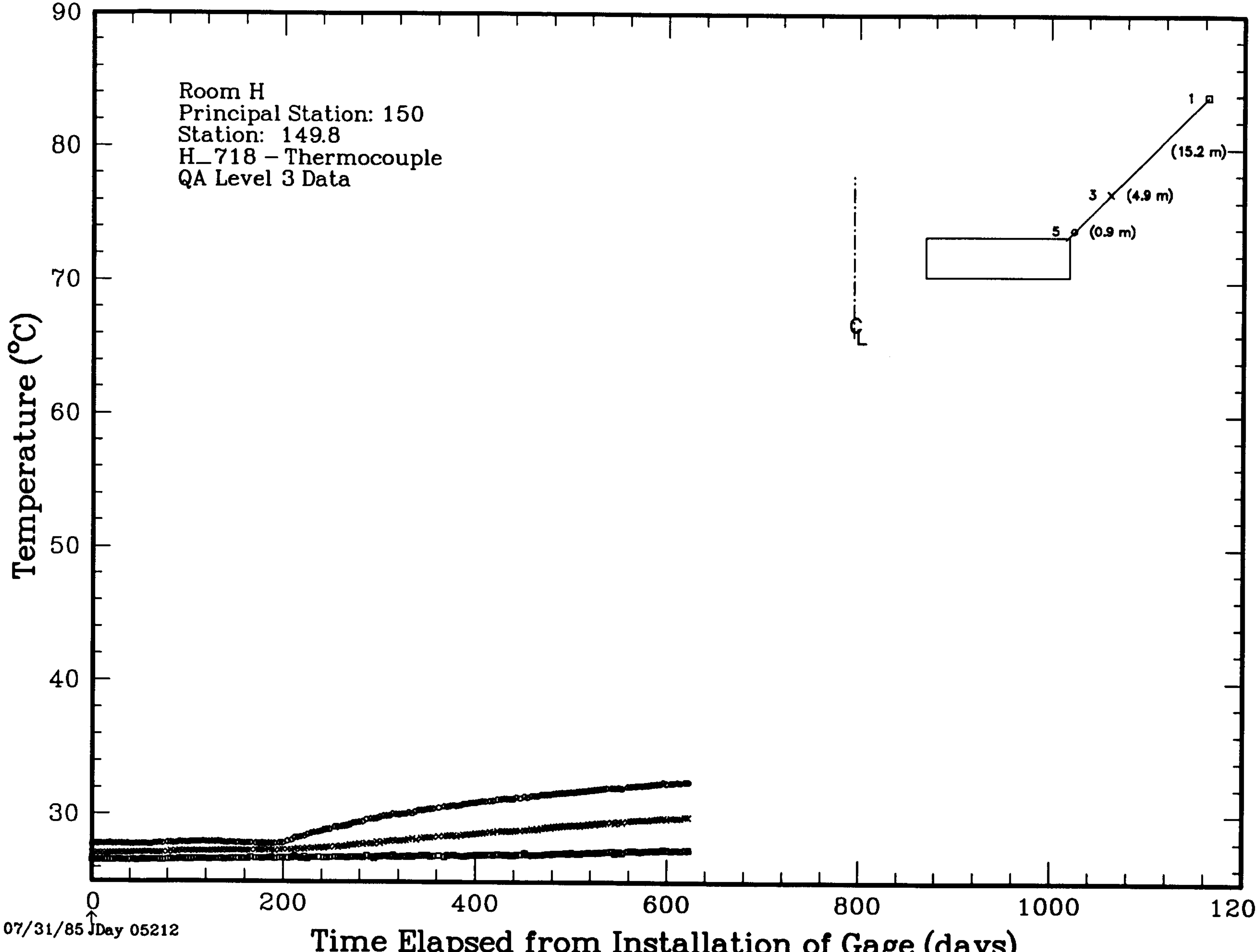

Figure 5.5.1o. Thermocouples, H 718

Table 5.5.1p. Thermocouples, H 719

Gage: H_719

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***** H_719 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(3),8(5)] THE SOMEWHAT HIGHER RESIDUAL SCATTER OF THESE DATA HAS RESULTED IN THE LOWER RANKING. EVEN THEN THE DATA ARE EXCELLENT. THE USUAL MINOR SCATTER HAS BEEN DELETED. [COMPRESSION 9.14:1] (DEM)

***** H_719 Location *****

Principal Station 150
Station 149.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_719-1	TC	P REM	D	16.15	26.88	149.95	149.95	-1.39	-12.16	-1.29	-12.07	ARI	06/10/85	65-2785#02	
H_719-3	TC	P REM	D	16.15	19.57	149.95	149.94	-1.39	-4.85	-1.29	-4.75	ARI	06/10/85	65-2786#08	
H_719-5	TC	P REM	D	16.15	16.77	149.95	149.95	-1.39	-2.05	-1.29	-1.95	ARI	06/10/85	65-2785#16	

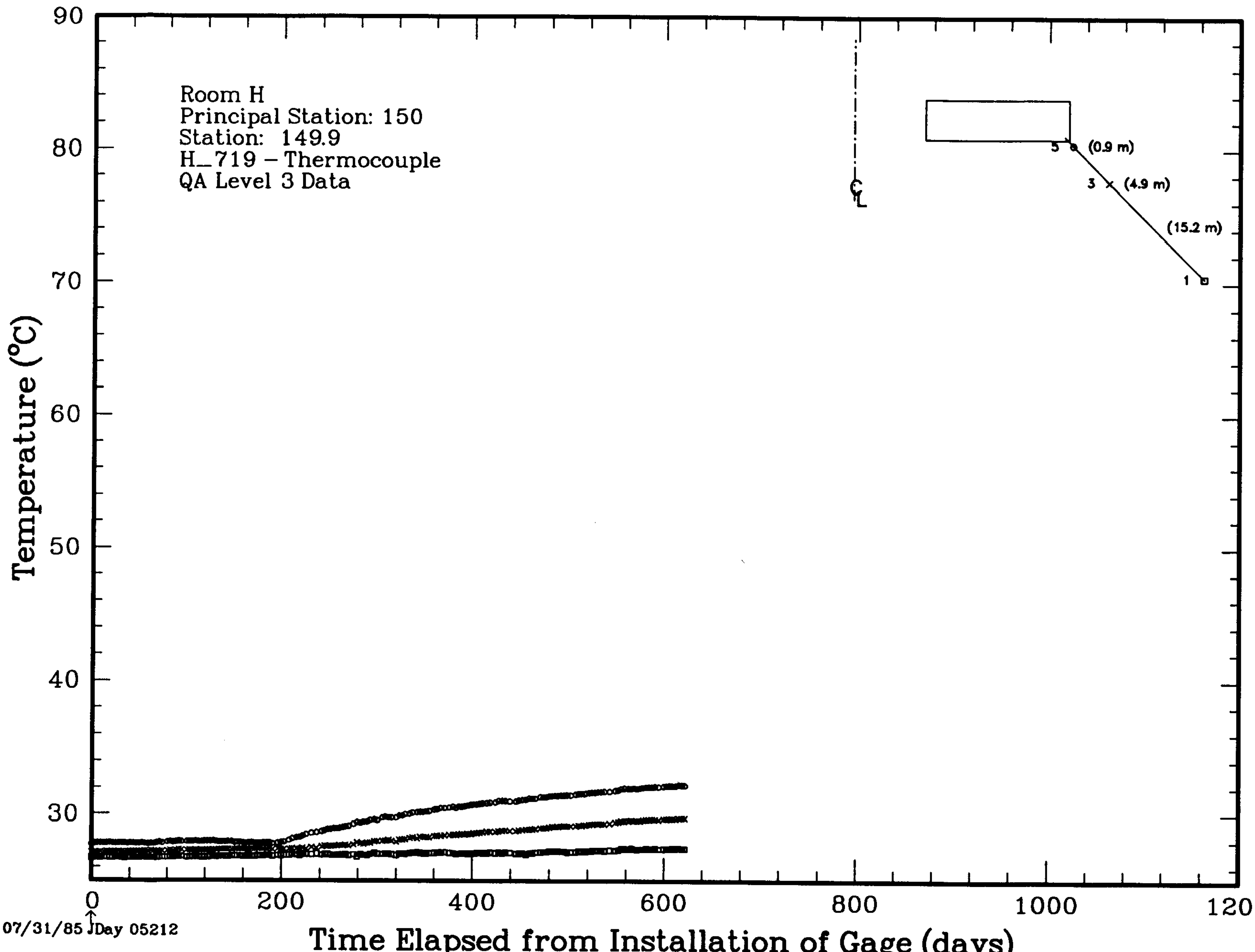

Figure 5.5.1p. Thermocouples, H 719

Table 5.5.1q. Thermocouples, H 720

+---------------------+
| Gage: H_720 |
+---------------------+
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***** H_720 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4)] ALL OF THESE GAGES ARE SLIGHTLY NOISY, WHICH IS REFLECTED IN THE RANKING OF 8. THE AVERAGE IS QUITE GOOD. MINOR SCATTER HAS BEEN REMOVED FROM ALL GAGES. [COMPRESSION 5.93:1] (DEM)

***** H_720 Location *****

Principal Station 270
Station 270.1

								Gage Coordinates							
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_720-1	TC	P REM	D	5.95	0.18	270.09	272.89	1.37	11.74	1.26	11.63	ARI	06/12/85	65-2785#02	
H_720-2	TC	P REM	D	5.95	2.73	270.09	270.19	1.37	7.17	1.26	7.06	ARI	06/12/85	65-2785#06	
H_720-3	TC	P REM	D	5.95	3.83	270.09	270.14	1.37	5.20	1.26	5.09	ARI	06/12/85	65-2785#10	
H_720-4	TC	P REM	D	5.95	4.87	270.09	270.11	1.37	3.33	1.26	3.22	ARI	06/12/85	65-2785#15	

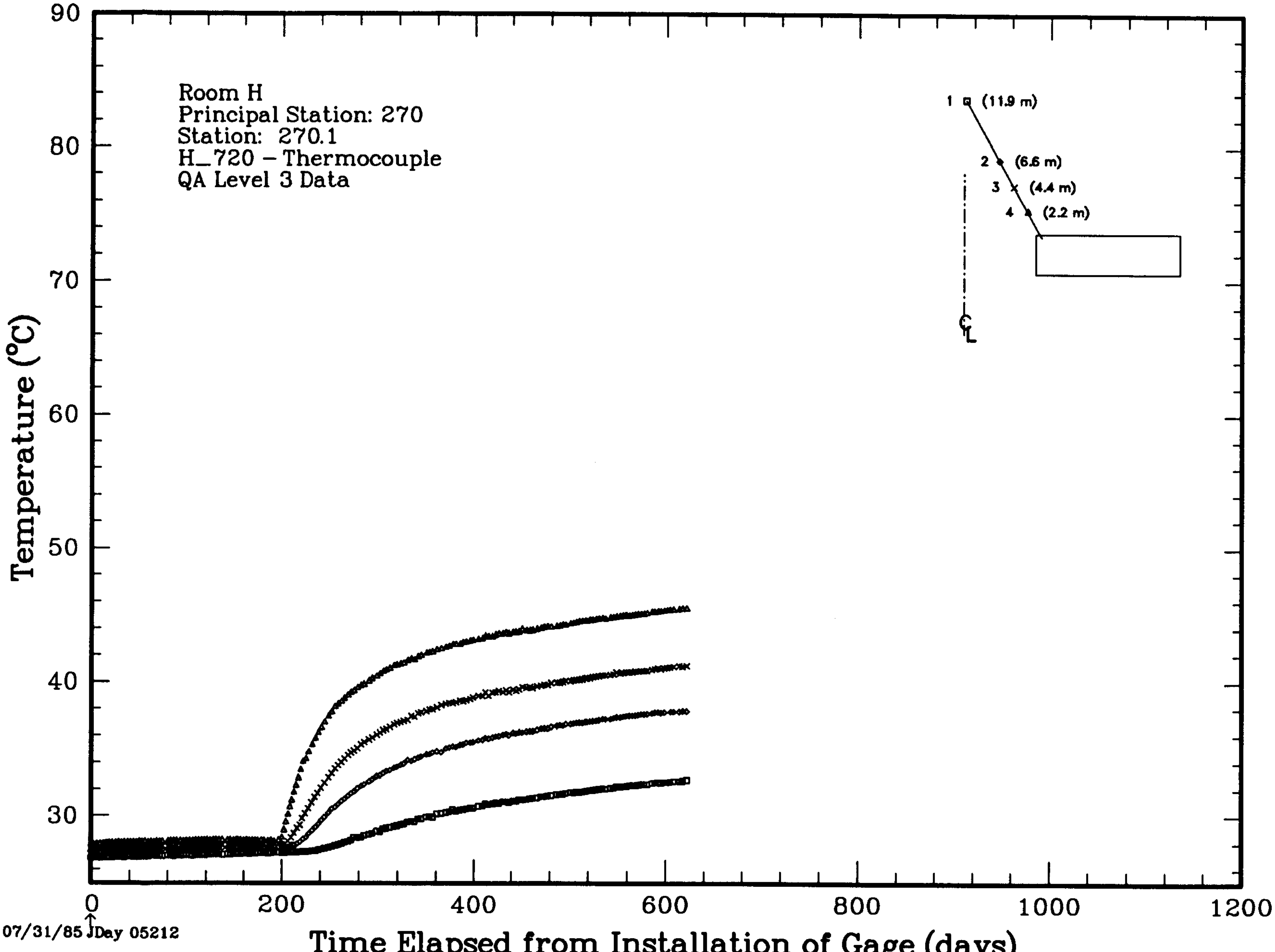

Figure 5.5.1q. Thermocouples, H 720

Table 5.5.1r. Thermocouples, H 721

Gage: H_721

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***** H_721 PI Comments *****

08/17/87 DLH [RANK = 8(1),7(2),8(3),8(4)] THE DATA HAD SOMEWHAT HIGHER UNCERTAINTY, WHICH CAUSED THE LOWER RANKING OF 8. GAGE 2 IN ADDITION HAD AN INTERVAL OF RESISTANCE SCATTER BETWEEN DAY 521 AND 561 WHICH WAS DELETED. THE USUAL MINOR DELETION OF RESISTANCE SCATTER WAS MADE ON ALL GAGES. [COMPRESSSION = 4.26:1] (DEM)

***** H_721 Location *****

Principal Station 270
Station 270.1

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_721-1	TC	P REM	D	5.72	0.85	270.09	270.61	1.23	6.10	1.12	5.99	ARI	06/12/85	65-2785#05	
H_721-2	TC	P REM	D	5.72	2.84	270.09	270.18	1.23	4.10	1.12	3.99	ARI	06/12/85	65-2785#09	
H_721-3	TC	P REM	D	5.72	3.99	270.09	270.13	1.23	2.94	1.12	2.84	ARI	06/12/85	65-2785#13	
H_721-4	TC	P REM	D	5.72	5.04	270.09	270.10	1.23	1.88	1.12	1.77	ARI	06/12/85	65-2785#16	

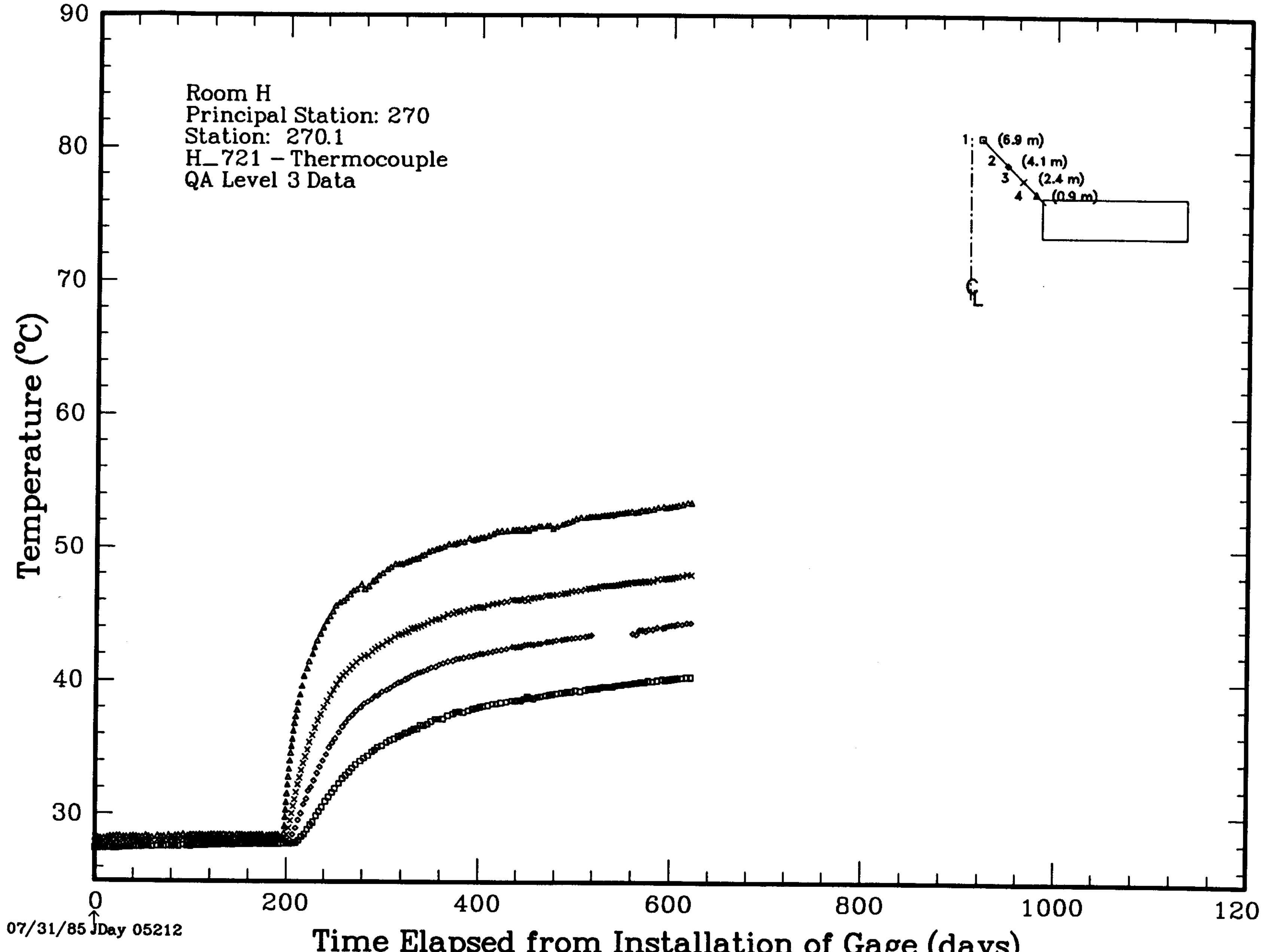

Figure 5.5.1r. Thermocouples, H 721

Table 5.5.1s. Thermocouples, H 722

Gage: H_722

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***** H_722 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4)] A SOMEWHAT HIGHER NOISE ON THESE RECORDS HAS RESULTED IN THE LOWER RANKING. HOWEVER, THE DATA ARE STILL EXCELLENT. MINOR DELETIONS OF RESISTANCE SCATTER WERE MADE ON ALL GAGES. [COMPRESSION = 4.82:1] (DEM)

***** H_722 Location *****

Principal Station 270
Station 270.2

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_722-1	TC	P REM	D	5.97	0.20	270.18	18.30	-1.60	-11.84	-1.71	-11.95	ARI	06/13/85	65-2785#02	
H_722-2	TC	P REM	D	5.97	2.58	270.18	272.50	-1.60	-7.33	-1.71	-7.44	ARI	06/13/85	65-2785#06	
H_722-3	TC	P REM	D	5.97	3.73	270.18	271.22	-1.60	-5.39	-1.71	-5.50	ARI	06/13/85	65-2785#10	
H_722-4	TC	P REM	D	5.97	4.80	270.18	270.62	-1.60	-3.54	-1.71	-3.65	ARI	06/13/85	65-2785#15	

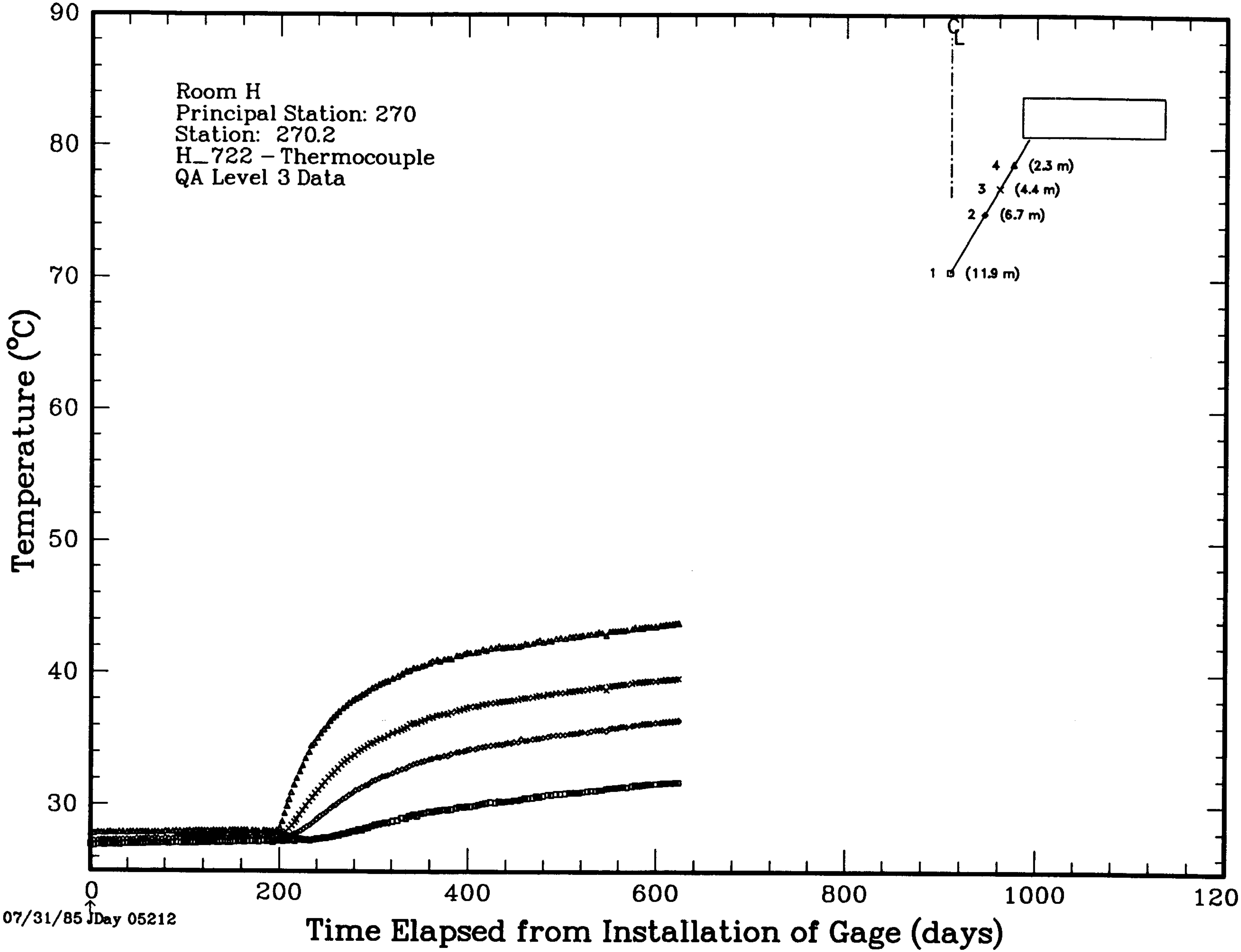

Figure 5.5.1s. Thermocouples, H 722

Table 5.5.1t. Thermocouples, H 723

Gage: H_723

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***** H_723 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4)] THE DATA OF THE UNIT ARE IN GENERAL EXCELLENT, WITH ONLY MINOR DELETIONS DUE TO NOISE. [COMPRESSION = 5.08:1] (DEM)

***** H_723 Location *****

Principal Station 270
Station 270.0

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_723-1	TC	P REM	D	5.73	0.89	269.97	273.73	-1.51	-6.39	-1.62	-6.50	ARI	06/12/85	65-2785#05	
H_723-2	TC	P REM	D	5.73	2.87	269.97	270.67	-1.51	-4.38	-1.62	-4.49	ARI	06/12/85	65-2785#09	
H_723-3	TC	P REM	D	5.73	4.01	269.97	270.26	-1.51	-3.23	-1.62	-3.33	ARI	06/12/85	65-2785#13	
H_723-4	TC	P REM	D	5.73	5.06	269.97	270.07	-1.51	-2.16	-1.62	-2.27	ARI	06/12/85	65-2785#16	

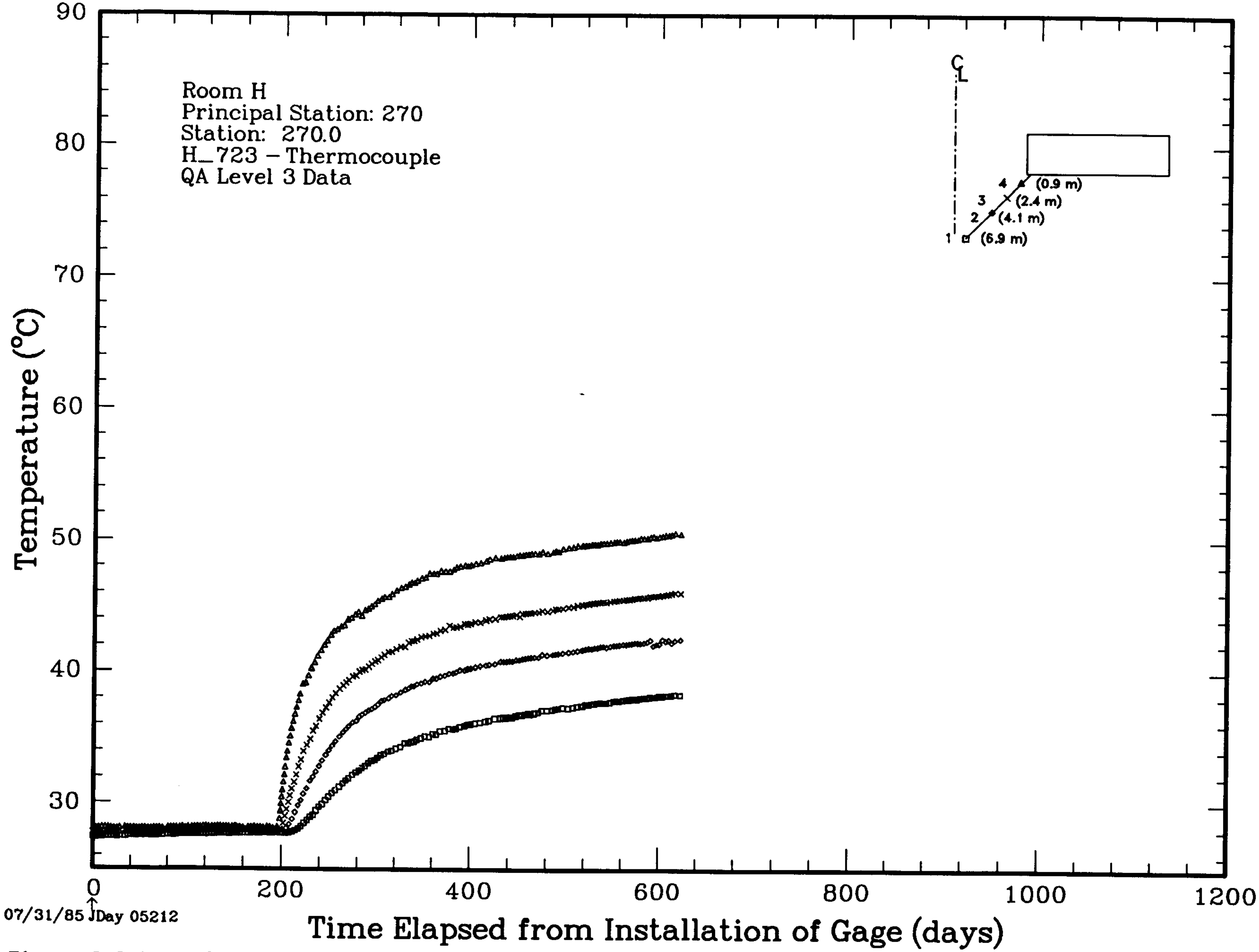

Figure 5.5.1t. Thermocouples, H 723

Table 5.5.1u. Thermocouples, H 724

Gage: H_724

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***** H_724 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4),8(5)] THE DATA ARE EXCELLENT. A SOMEWHAT GREATER UNCERTAINTY IS SEEN WHICH PREVENTS THE DATA FROM HAVING A HIGHER RANKING. DELETION OF MINOR SCATTER OCCURRED FOR ALL GAGES. [COMPRESSION 6.53:1] (DEM)

***** H_724 Location *****

Principal Station 270
Station 269.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_724-1	TC	P REM	D	16.29	26.97	269.91	270.14	1.27	12.12	1.17	12.01	ARI	06/11/85	65-2785#02	
H_724-2	TC	P REM	D	16.29	22.69	269.91	270.08	1.27	7.78	1.17	7.67	ARI	06/11/85	65-2785#03	
H_724-3	TC	P REM	D	16.29	19.69	269.91	270.01	1.27	4.75	1.17	4.65	ARI	06/11/85	65-2785#08	
H_724-4	TC	P REM	D	16.29	17.55	269.91	269.95	1.27	2.59	1.17	2.48	ARI	06/11/85	65-2785#14	
H_724-5	TC	P REM	D	16.29	16.91	269.91	269.94	1.27	1.94	1.17	1.83	ARI	06/11/85	65-2785#16	

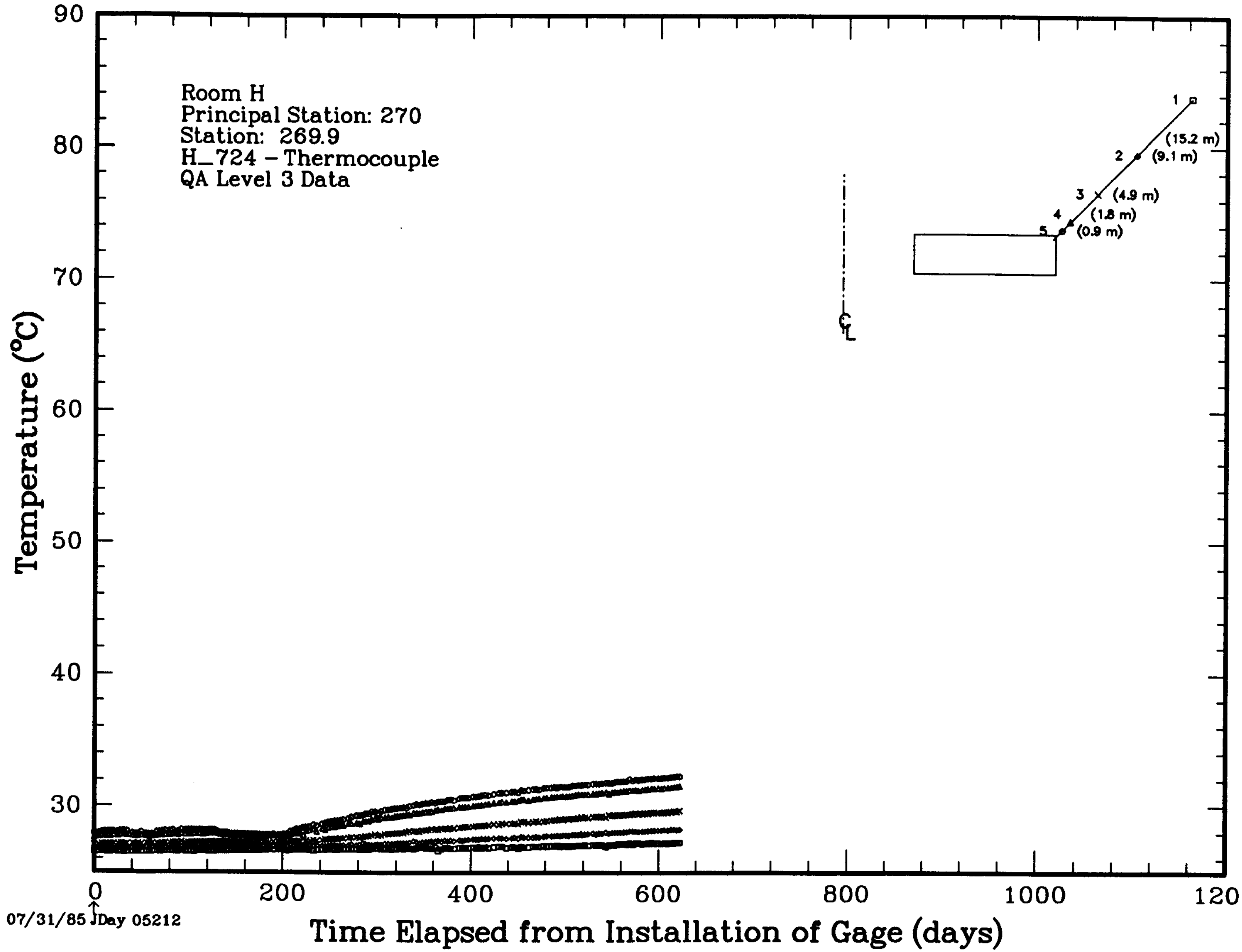

Figure 5.5.1u. Thermocouples, H 724

Table 5.5.1v. Thermocouples, H 725

Gage: H_725

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***** H_725 PI Comments *****

08/17/87 DLH [RANK = 8(1),8(2),8(3),8(4),8(5)] THE UNIT HAS EXCELLENT DATA. THE RANK OF 8 REFLECTS THE SOMEWHAT HIGHER RESIDUAL SCATTER OF DATA. AS USUAL THE MINOR DELETION OF CONTACT RESISTANCE SCATTER OCCURRED FOR THESE GAGES. [COMPRESSION = 6.08:1] (DEM)

***** H_725 Location *****

Principal Station 270
Station 270.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_725-1	TC	P REM	D	16.25	26.99	270.04	269.79	-1.52	-12.30	-1.63	-12.41	ARI	06/11/85	65-2785#02	
H_725-2	TC	P REM	D	16.25	22.68	270.04	269.86	-1.52	-8.00	-1.63	-8.11	ARI	06/11/85	65-2785#03	
H_725-3	TC	P REM	D	16.25	19.67	270.04	269.93	-1.52	-4.98	-1.63	-5.09	ARI	06/11/85	65-2785#08	
H_725-4	TC	P REM	D	16.25	17.52	270.04	270.00	-1.52	-2.83	-1.63	-2.94	ARI	06/11/85	65-2785#14	
H_725-5	TC	P REM	D	16.25	16.88	270.04	270.02	-1.52	-2.19	-1.63	-2.30	ARI	06/11/85	65-2785#16	

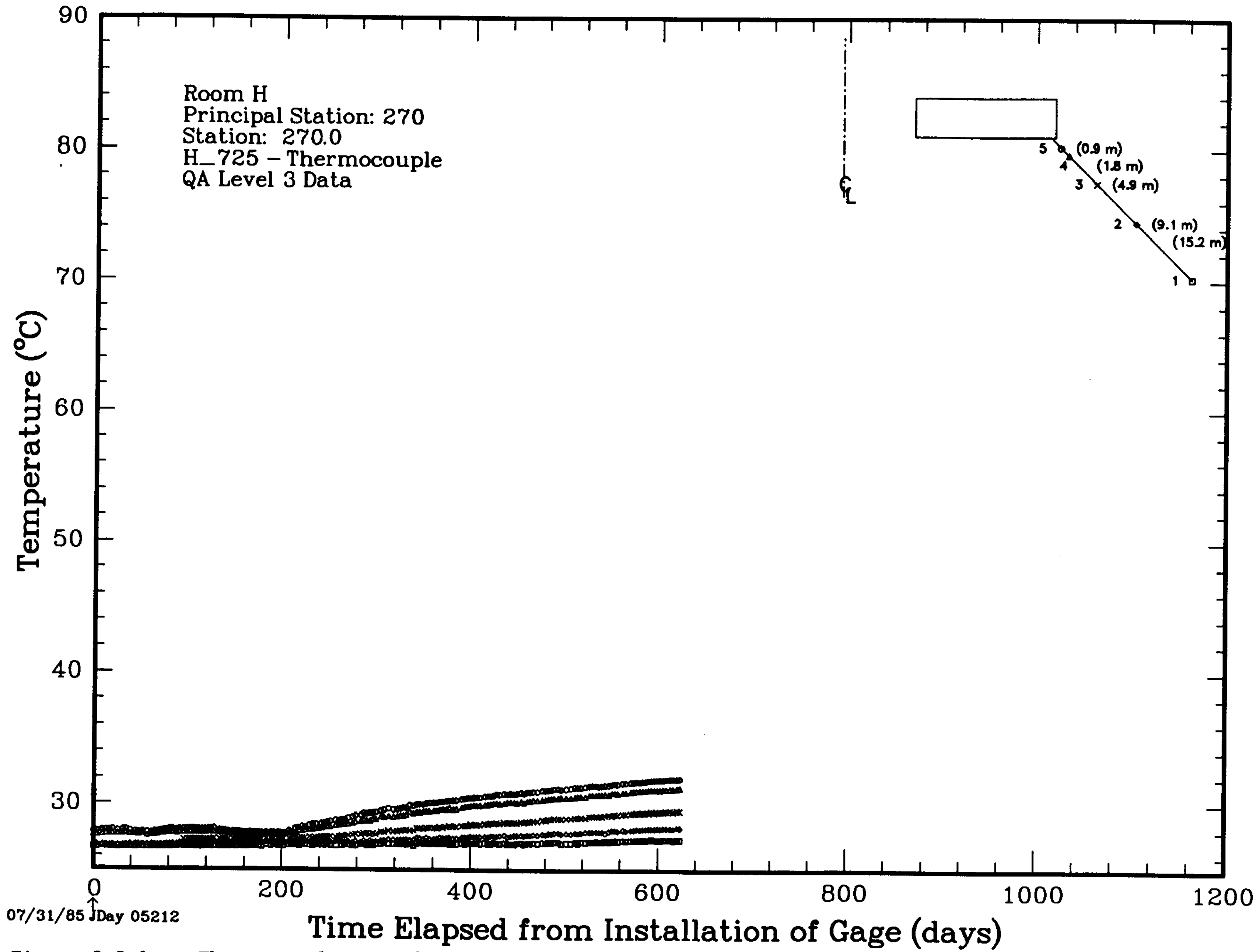

Figure 5.5.1v. Thermocouples, H 725

Table 5.5.1w. Thermocouples, H 726

Gage: H_726

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***** H_726 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),9(3),5(4)] THE DATA ARE ALL EXCEPTIONAL, EXCEPT FOR GAGE 4 WHERE SEVERE CONTACT RESISTANCE SCATTER REQUIRED DELETION OF DATA BETWEEN DAY 300 AND 623. MINOR DELETIONS OF SCATTERED DATA OCCURRED ON ALL GAGES. [COMPRESSION = 1.87:1] (DEM)

***** H_726 Location *****

Principal Station 030
Station 29.8

Gage Number	Gage Type	Rec	Dir	Gage Coordinates Prin Stat R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_726-1	TC	P REM	D	6.02	0.96	29.82	29.58	1.43	8.08	1.48	8.12	ARI	06/12/85	65-2785#04	
H_726-2	TC	P REM	D	6.02	2.48	29.82	29.78	1.43	6.07	1.48	6.12	ARI	06/12/85	65-2785#07	
H_726-3	TC	P REM	D	6.02	3.71	29.82	29.83	1.43	4.46	1.48	4.50	ARI	06/12/85	65-2785#11	
H_726-4	TC	P REM	D	6.02	4.93	29.82	29.84	1.43	2.80	1.48	2.85	ARI	06/12/85	65-2785#16	

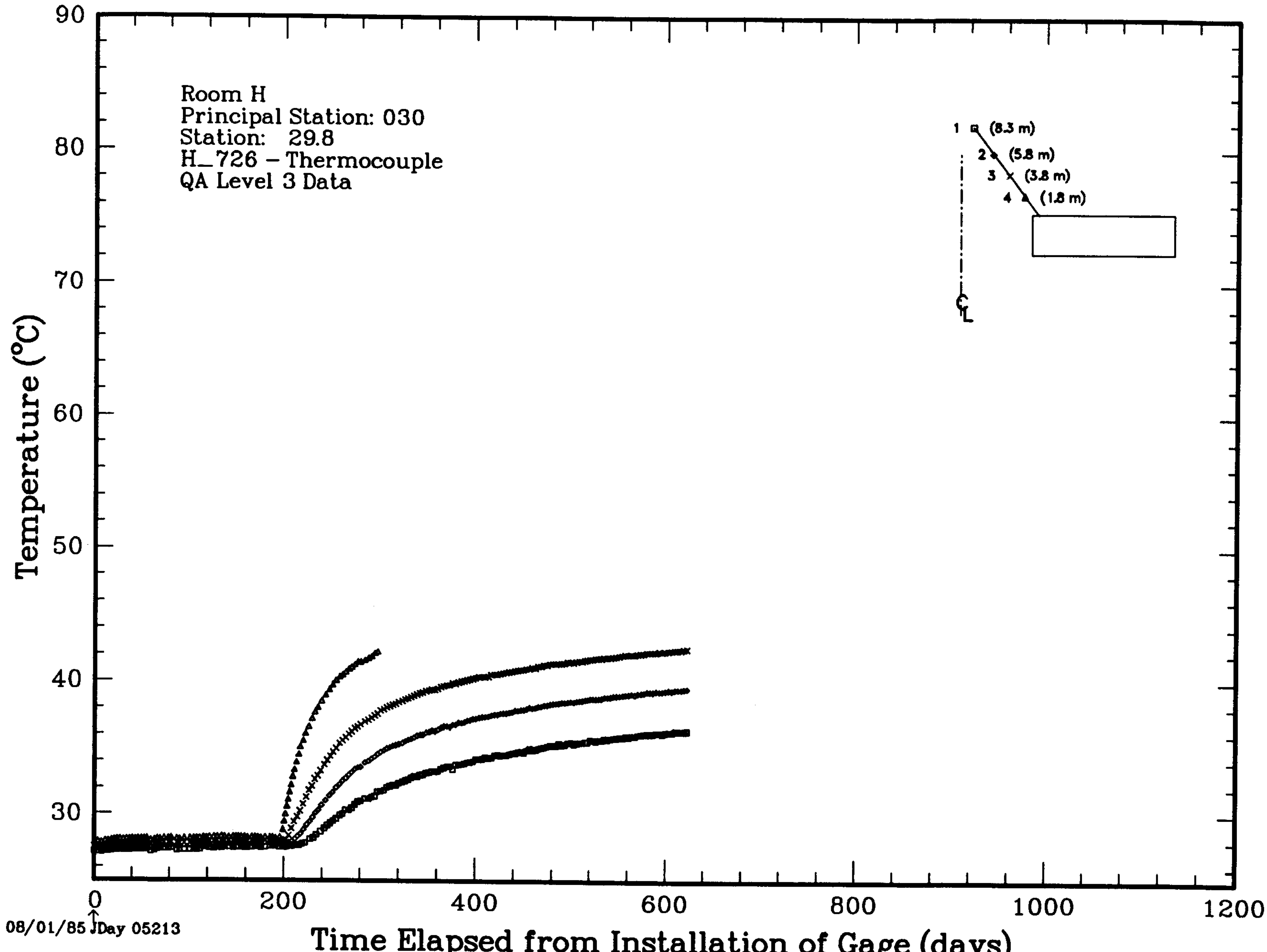

Figure 5.5.1w. Thermocouples, H 726

Table 5.5.1x. Thermocouples, H 727

Gage: H_727

****

***** H_727 PI Comments *****

08/17/87 DLH [RANK = 9(1),6(2),7(3),9(4)] THE DATA QUALITY FOR THESE GAGES IS EXCEPTIONAL, EXCEPT THAT SOME LARGE SEGMENTS OF DATA HAVE BEEN DELETED FOR CONTACT RESISTANCE SCATTER IN GAGES 2 AND 3 WHICH ACCOUNTS FOR THE LOWER RANKINGS. DATA WAS DELETED FROM GAGE 2 BETWEEN DAYS 354 AND 539, AND FROM GAGE 3 BETWEEN DAYS 540 AND 623. MINOR AMOUNTS OF OTHER SCATTER WAS REMOVED FROM ALL GAGES. [COMPRESSION = 2.24:1] (DEM)

***** H_727 Location *****

Principal Station 030
Station 29.9

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_727-1	TC	P REM	D	5.82	1.25	29.89	29.39	1.35	3.97	1.39	4.02	ARI	06/13/85	65-2785#07	
H_727-2	TC	P REM	D	5.82	2.76	29.89	29.76	1.35	3.10	1.39	3.14	ARI	06/13/85	65-2785#10	
H_727-3	TC	P REM	D	5.82	3.99	29.89	29.83	1.35	2.39	1.39	2.43	ARI	06/13/85	65-2785#13	
H_727-4	TC	P REM	D	5.82	5.21	29.89	29.87	1.35	1.69	1.39	1.73	ARI	06/13/85	65-2785#17	

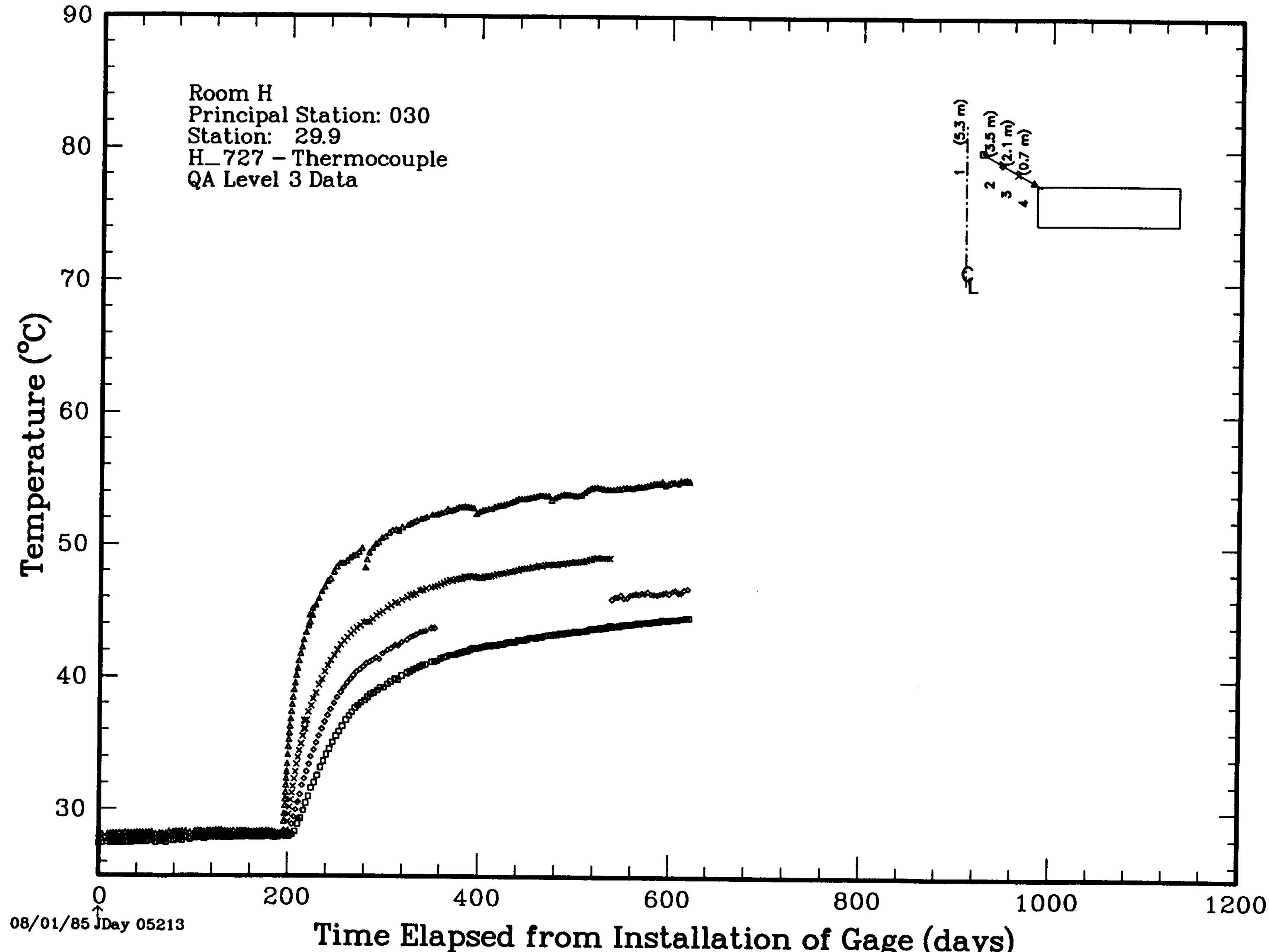

Figure 5.5.1x. Thermocouples, H 727

Table 5.5.1y. Thermocouples, H 728

Gage: H_728

****

***** H_728 PI Comments *****

08/17/87 DLH [RANK = 9(1),9(2),7(3),9(4)] ALL THE DATA OF THE UNIT ARE EXCEPTIONAL. GAGE 3 HAS A LOWER RANKING ONLY BECAUSE OF CONTACT RESISTANCE SCATTER THAT WAS DELETED BETWEEN DAY 309 AND 438. SMALL AMOUNTS OF OTHER SCATTER WERE DELETED FROM ALL GAGES. [COMPRESSION = 4.80:1] (DEM)

***** H_728 Location *****

Principal Station 030
Station 29.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_728-1	TC	P REM	D	5.97	0.73	29.75	28.07	-1.43	-7.94	-1.38	-7.89	ARI	06/12/85	65-2785#04	
H_728-2	TC	P REM	D	5.97	2.30	29.75	29.35	-1.43	-5.98	-1.38	-5.93	ARI	06/12/85	65-2785#07	
H_728-3	TC	P REM	D	5.97	3.58	29.75	29.60	-1.43	-4.39	-1.38	-4.35	ARI	06/12/85	65-2785#11	
H_728-4	TC	P REM	D	5.97	4.84	29.75	29.68	-1.43	-2.77	-1.38	-2.72	ARI	06/12/85	65-2785#16	

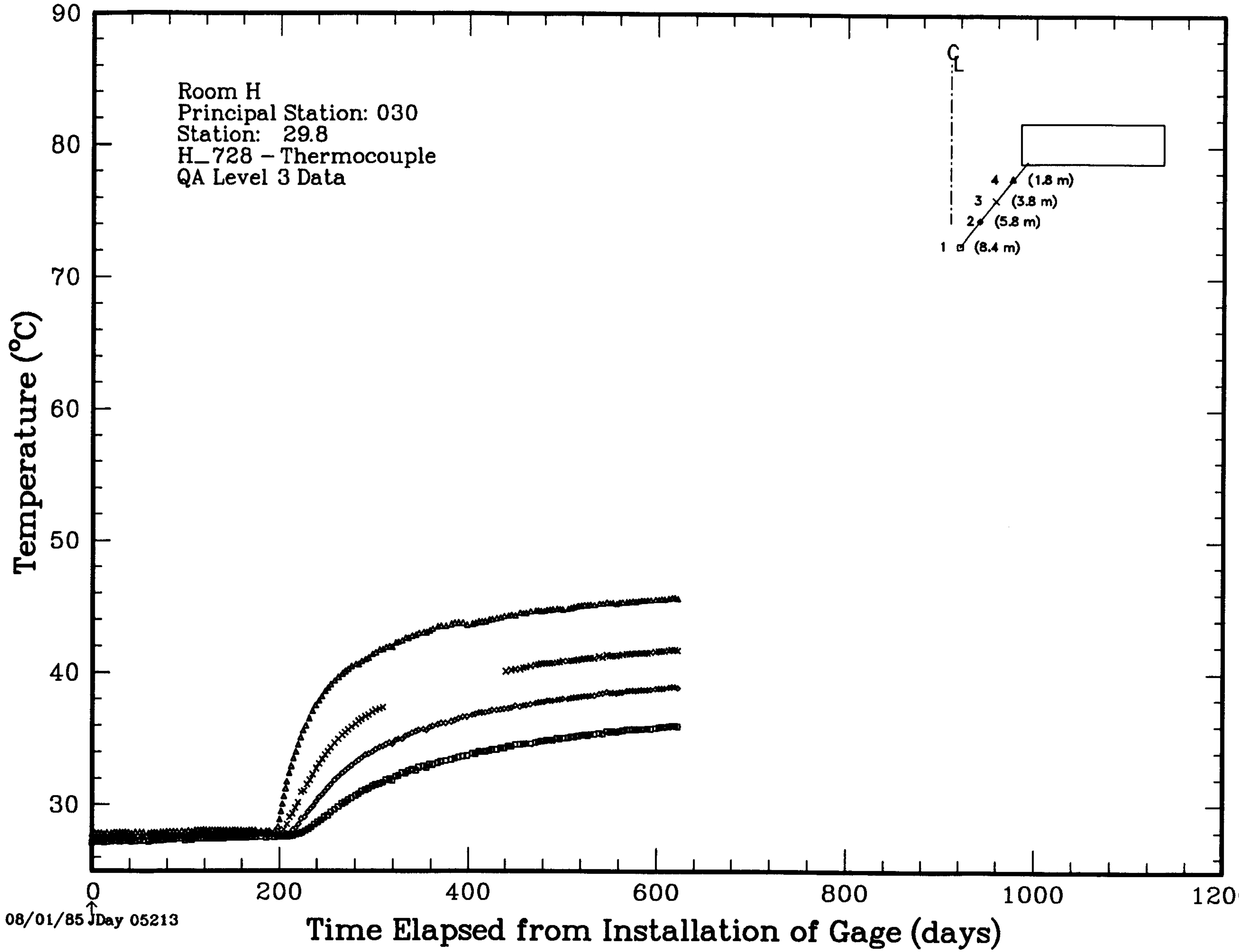

Figure 5.5.1y. Thermocouples, H 728

Table 5.5.1z. Thermocouples, H 729

Gage: H_729

****

***** H_729 PI Comments *****

08/17/87 DLH [RANK = 9(1),7(2),9(3),9(4)] ALL THE DATA ARE EXCEPTIONAL, EXCEPT GAGE 2 HAS A GROUP OF CONTACT RESISTANCE SCATTER THAT WAS DELETED BETWEEN DAY 350 AND 584 TO LOWER THE QUALITY. MINOR DELETIONS OF DATA SCATTER OCCURRED ON ALL GAGES. [COMPRESSION = 2.87:1] (DEM)

***** H_729 Location *****

Principal Station 030
Station 30.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Gage Coordinates Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_729-1	TC	P REM	D	5.74	1.12	30.03	28.79	-1.35	-3.99	-1.31	-3.94	ARI	06/13/85	65-2785#07	
H_729-2	TC	P REM	D	5.74	2.65	30.03	29.78	-1.35	-3.11	-1.31	-3.07	ARI	06/13/85	652785#10	
H_729-3	TC	P REM	D	5.74	3.89	30.03	29.88	-1.35	-2.40	-1.31	-2.35	ARI	06/13/85	65-2785#13	
H_729-4	TC	P REM	D	5.74	5.11	30.03	29.98	-1.35	-1.70	-1.31	-1.65	ARI	06/13/85	65-2785#17	

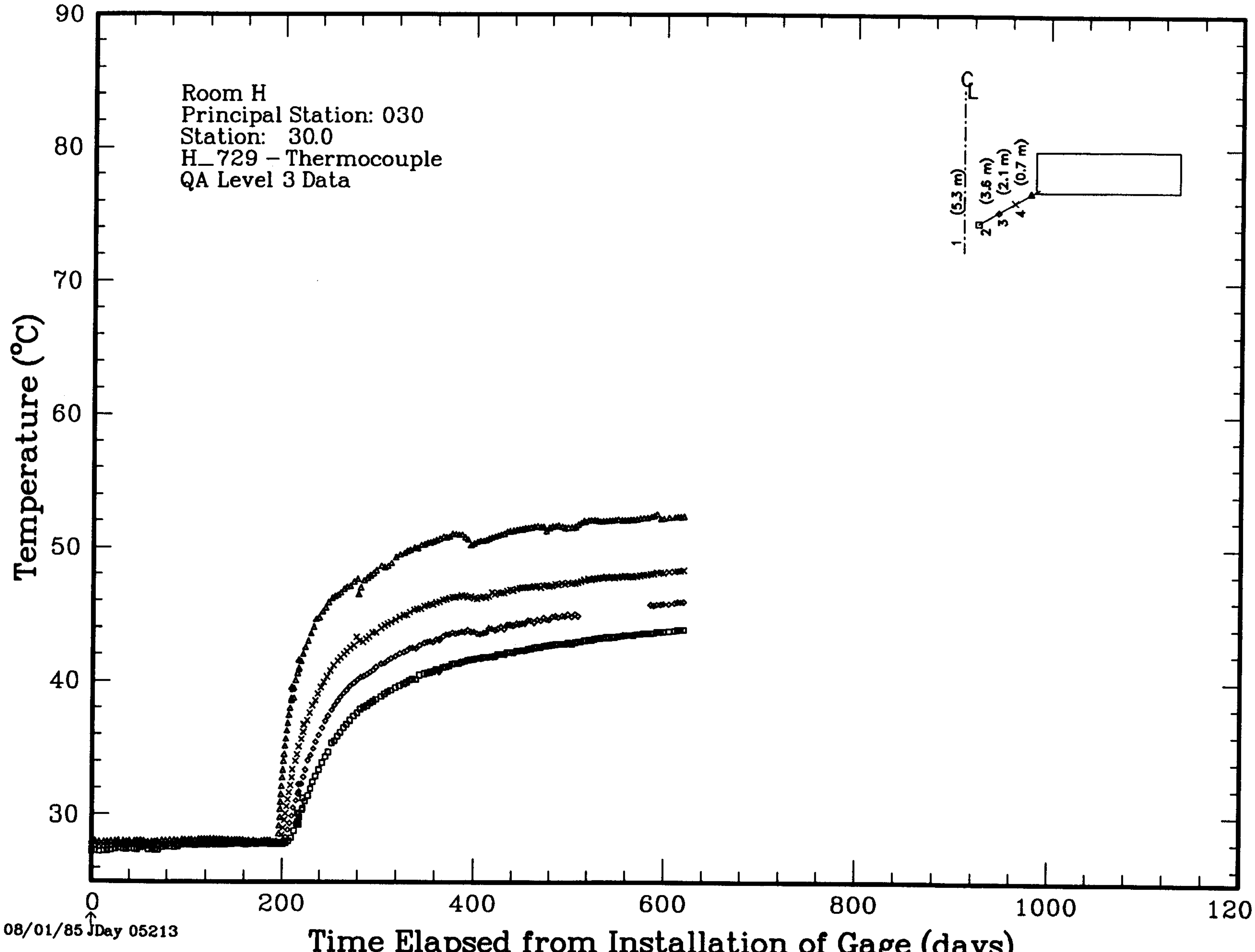

Figure 5.5.1z. Thermocouples, H 729

5.6 Heat Flux Measurements

The flux meters used in this test are essentially pillar surface emplacements. As illustrated schematically in Table 5.6.1, H F01 and H F02 (deepest) are at pillar midheight and diametrically opposed to the similar midheight emplacement set of H F33 and H F34 (deepest). H F31 and H F32 are at various heights directly above H F34, and H F35 and H F36 are at various heights directly below H F34.

The flux meter unit is a mixed gage unit, with H Fxx-1 a thermopile for measuring heat flux and H Fxx-2 a thermocouple for measuring the thermopile temperature. In all gages, the direction of the unit normal to the thermopile substrate was radial, with positive flux into the pillar.

Specific information about these units is given in Tables 5.6.1a-h. Combined plots of flux and temperature for each unit are given in Figures 5.6.1a-h. The flux is always gage 1, with square symbols; and the temperature is always gage 2, with diamond symbols.

At first glance, the flux measurements are perhaps the most confusing of all the test data. An understanding of the following comments is therefore important to place the measurements in proper context. Flux meters are very small, delicate, one-dimensional (1-D) gages. They are also very sensitive. These special gages were emplaced in a field environment that, although controlled, was not controlled at the scale of these gages. The periodicity of the heating tapes around the pillar surface was planned to be about the same as the depth of the flux meter emplacements were beneath the pillar surface. The specific intent of the geometrical arrangement was to place the flux meters sufficiently far beneath the pillar surface to smooth the thermal front produced by the nonuniform pillar surface heating of the discrete heater tapes. The perturbation of the thermal front was expected to extend into the pillar about one-half of the heater tape spacing. The additional radial depth to the flux should have insured a nearly 1-D flux condition.

In fact, the periodicity of the heating tapes was initially abnormally large at the flux meter emplacements. Further, field maintenance of the heater tapes and insulation, although considered superior for a large field test, was too crude for acceptable heat flux measurements. Keeping these factors in mind, we now examine the heat flux data.

The data include the temperatures from the thermocouple junctions attached directly to the substrate of the flux gages. The measured temperatures are scalar quantities, and the flux values are the vector components of the heat flow resolved in the direction normal to the flux meter. Now, let us examine the H F01 data (Figure 5.6.1a) because they show the most pronounced effects. When the heating started, the temperature at the gage increased in what seemed a normal manner. However, the heat flux according to the data is negative, which means that the correct interpretation is that heat was flowing from the pillar interior towards the pillar surface. The large heater tape spacing and the poorly maintained or deficient insulation at the gage produced 3-D thermal flows at the gage so that the temperature increased from lateral heat fluxes. The gage records during this early period show that the measured fluxes range from negative to zero (the gage indicates zero when all flux is transverse to the gage normal) to positive. Although impossible to discern from the independent temperature records, the 3-D heat flow caused the temperatures to be lower than for well-controlled

Table 5.6.1. Flux Meter Units (Gages) Location Guide

Station	Direction		Relative Location: pillar	center	rib
H ST025		roof			
	Horizontal	5/6			
	Horizontal	2/3			
	Horizontal	1/2	H F02,H F01		
	Horizontal	1/3			
	Horizontal	1/6			
		floor			
H ST270		roof			
	Horizontal	5/6	H F31		
	Horizontal	2/3	H F32		
	Horizontal	1/2	H F34,H F33		
	Horizontal	1/3	H F35		
	Horizontal	1/6	H F36		
		floor			

radial, 1-D heat flow. When these effects were understood, the heater tape spacing was adjusted and insulation was correctly placed at the flux meter locations. The first attempt on day 279 (Jday 6160) in some cases placed heater tapes directly over the flux meter; both the temperature and flux increased markedly. With further understanding, the next corrective action on day 353 (Jday 6234) adjusted the space and insulation properly with a corresponding decrease in flux and temperature. Thereafter, the flux measurements appear reasonable and more uniform among the gages. However, it should be noted that the gage H F36-1 flux seems somewhat larger than the other gages after the final adjustment of the heater tapes and insulation. This coupled with a significant amount of scatter on the data might suggest this gage has failed. Probably the only method to determine the reasonableness of the data is through numerical analysis.

In fact, the rather difficult experimental conditions for fielding of these gages and the extreme sensitivity of these gages to the local conditions mean that the results should be used with caution, until such time as an analysis confirms the correct interpretation of the data.

Table 5.6.1a. Flux Meters, H F01

Gage: H_F01

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***** H_F01 PI Comments *****

09/24/87 DLH:DEM [RANK = 9(1),9(2)] THE FLUX DATA ARE EXCEPTIONAL AND THE TEMPERATURE DATA HAS BETTER THAN 90% RETENTION. BEFORE DAY 279 (JDAY 6160), IT HAD BEEN NOTICED THAT THE THERMAL INSULATION ON THE PILLAR WAS GRADUALLY BEING SHIFTED BY THE PILLAR DEFORMATION WHICH RESULTED IN A LOCAL GAP. THIS CAUSED THE FLUX TO GRADUALLY DECLINE. ON DAY 279, THE INSULATION BLANKETS WERE REARRANGED; APPARENTLY THIS CAUSED THE HEATER ELEMENTS TO CLUSTER OVER THE GAGE AND RESULTED IN A LOCALLY HIGHER FLUX. DURING A CHECK, CRACKS IN THE PILLAR WERE FOUND AND PHOTOGRAPHED ON DAY 353; AT THIS TIME, THE HEATER ELEMENTS WERE REPOSITIONED TO THEIR CORRECT LOCATIONS AND THE FLUX DECREASED. THE GAGE 2 TEMPERATURE RECORD REFLECTS THE SEQUENCE OF EVENTS AND WITH THE PROPER INTERPRETATION SUBSTANTIATES THE FLUX DATA. [COMPRESSION 13.0:1] (DEM)

***** H_F01 Location *****

Principal Station SPEC
Station 24.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F01-1	TPL	P REM	H	5.59	5.51	24.15	24.15	-0.15	-0.15	-0.11	-0.11	RDF	08/26/85	25-5753A#0	X+0.913Y+0.408Z 0.000
H_F01-2	TC	P REM	H	5.59	5.51	24.15	24.15	-0.15	-0.15	-0.11	-0.11	RDF	08/26/85	25-5753A#0	

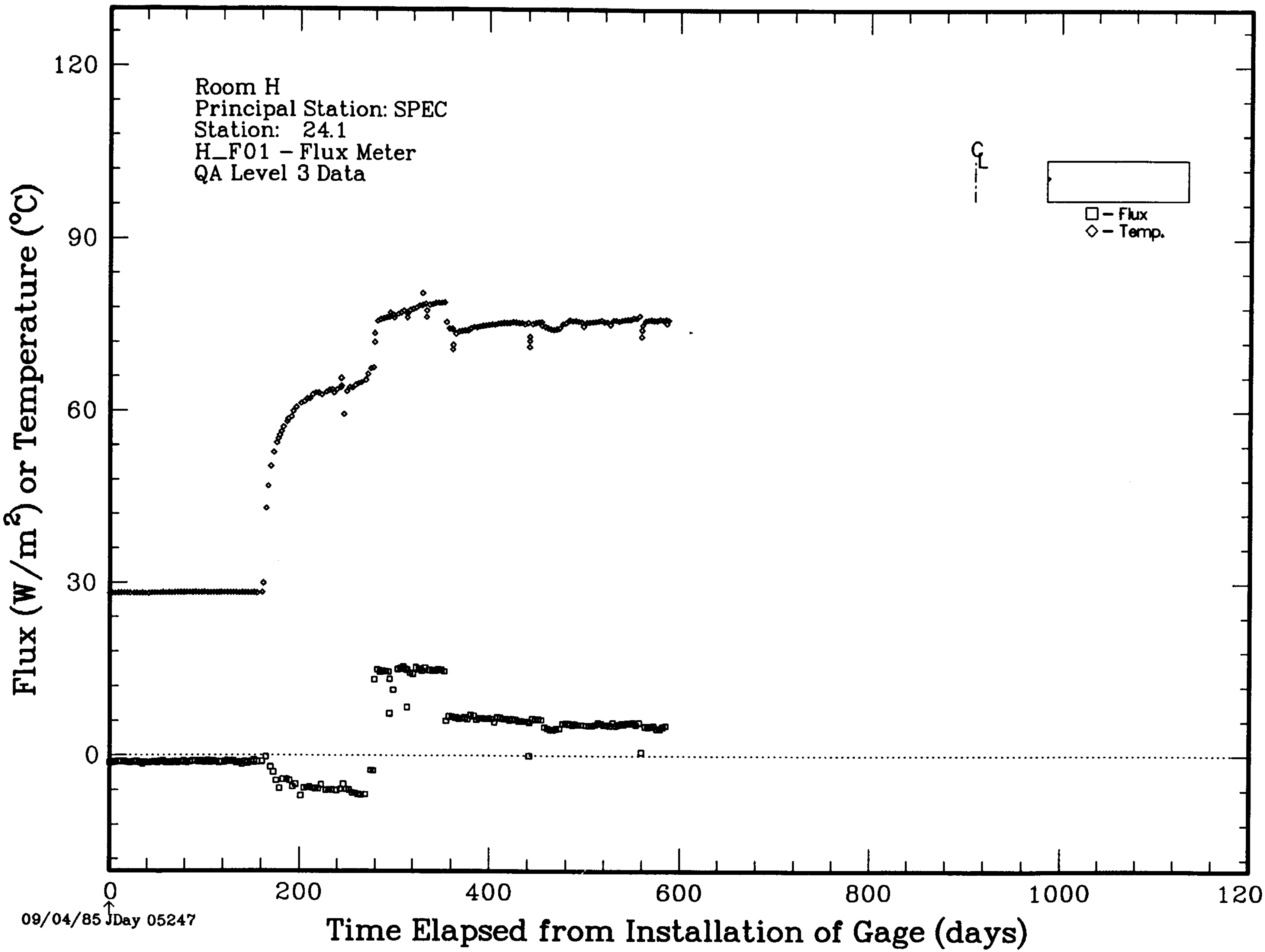

Figure 5.6.1a. Flux Meters, H F01

Table 5.6.1b. Flux Meters, H F02

Gage: H_F02

****

***** H_F02 PI Comments *****

09/24/87 DLH [RANK = 9(1),9(2)] THE FLUX DATA ARE EXCEPTIONAL AND THE TEMPERATURE DATA RETENTION IS BETTER THAN 90%. AT EARLY TIMES, PRIOR TO DAY 279, THE PILLAR INSULATION GRADUALLY DETERIORATED BY SEPARATIONS AND OTHER PILLAR DEFORMATION MOTIONS; THIS CAUSED THE TEMPERATURE AND FLUX VALUES TO DECREASE BY HEAT LOSS BETWEEN INSULATION SECTIONS. THE INSULATION WAS REARRANGED ON DAY 279 WHICH CORRECTED THE PROBLEM PARTIALLY. APPARENTLY, THIS ALSO CAUSED THE HEATER ELEMENTS TO BUNCH LOCALLY. ON DAY 353, THE INSULATION BLANKET WAS REMOVED TO PHOTOGRAPH THE PILLAR AND THE HEATER ELEMENTS WERE REPOSTI0NED AT THAT TIME CAUSING THE FLUX AND TEMPERATURE TO DECREASE. THE FLUX METER FAILED ON DAY 546. [COMPRESSION 8.18:1] (DEM)

***** H_F02 Location *****

Principal Station SPEC
Station 24.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F02-1	TPL	P REM	H	5.59	5.39	24.15	24.14	-0.15	-0.15	-0.11	-0.11	RDF	08/26/85	25-5753A#0	X+0.913Y+0.408Z 0.000
H_F02-2	TC	P REM	H	5.59	5.39	24.15	24.14	-0.15	-0.15	-0.11	-0.11	RDF	08/26/85	25-5753A#0	

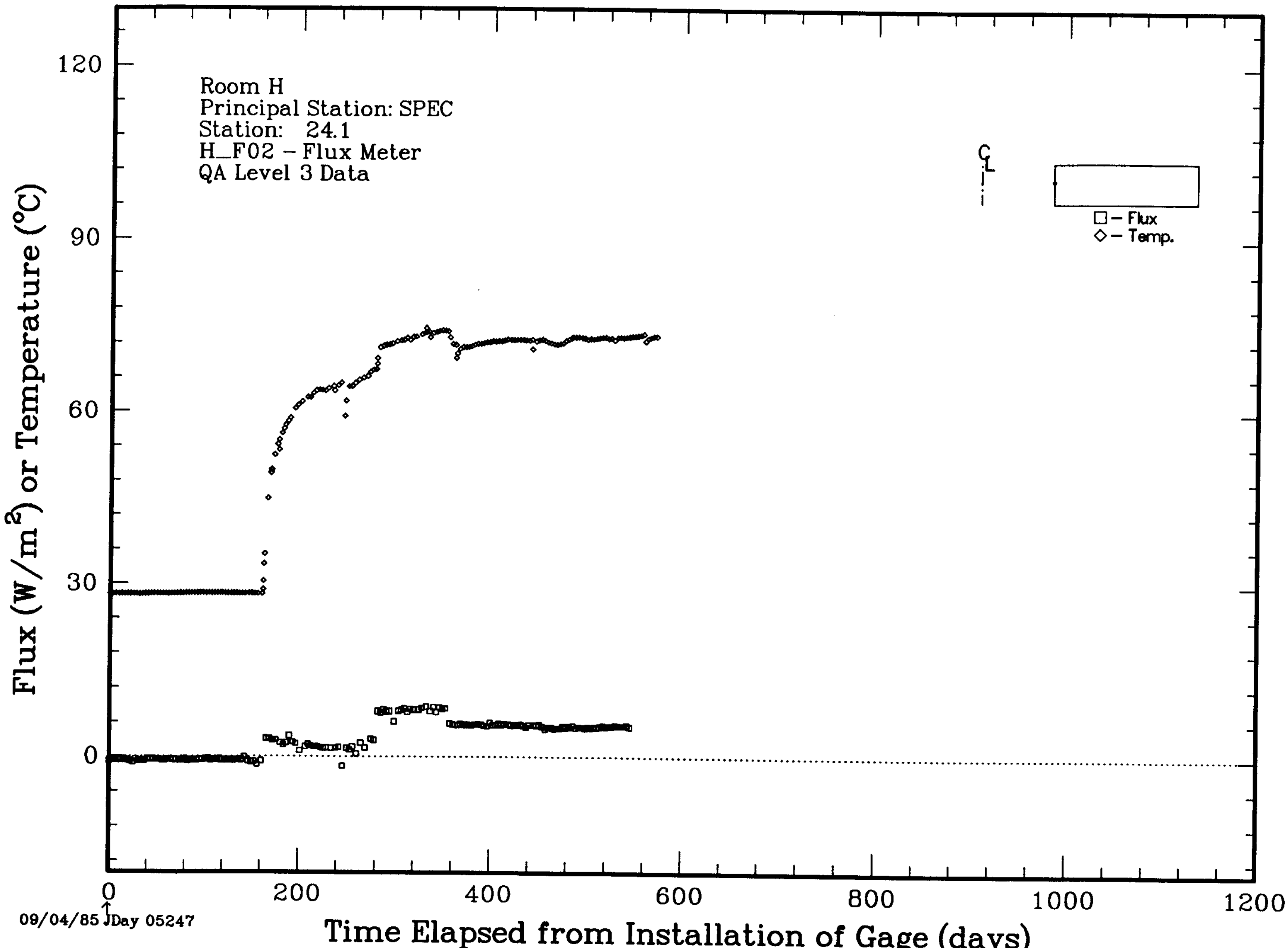

Figure 5.6.1b. Flux Meters, H F02

Table 5.6.1c. Flux Meters, H F31

Gage: H_F31

****

***** H_F31 PI Comments *****

09/24/87 DKH [RANK = 8(1),9(2)] THE FLUX DATA SHOW SOME SCATTER WHICH ACCOUNTS FOR THE EXCELLENT RANKING; THE THERMOCOUPLE DATA HAD BETTER THAN 90% RETENTION. AS WITH ALL THE FLUX GAGES IN THE PILLAR, THE GRADUAL DETERIORATION OF THE FIT OF THE INSULATION BLANKET WITH TIME AS THE PILLAR DEFORMED CAUSED THE BLANKET TO DEVELOPE GAPS AND THE HEATER ELEMENTS TO CHANGE POSITION AND FALL AWAY FROM THE PILLAR. WHEN THIS WAS CORRECTED ON DAY 279, THE FLUX RETURNED TO THE MORE CORRECT AND HIGHER VALUE. THE DETERIORATION IN THE INSULATION SHOWS ONLY SLIGHTLY ON THE TEMPERATURE RECORD. [COMPRESSION = 12.16:1] (DEM)

***** H_F31 Location *****

Principal Station SPEC
Station 264.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F31-1	TPL	P REM	H	5.59	5.50	263.99	263.99	0.85	0.85	0.74	0.74	RDF	08/27/85	25-5753A#0	X+0.104Y+0.994Z 0.000
H_F31-2	TC	P REM	H	5.59	5.50	263.99	263.99	0.85	0.85	0.74	0.74	RDF	08/27/85	25-5753A#0	

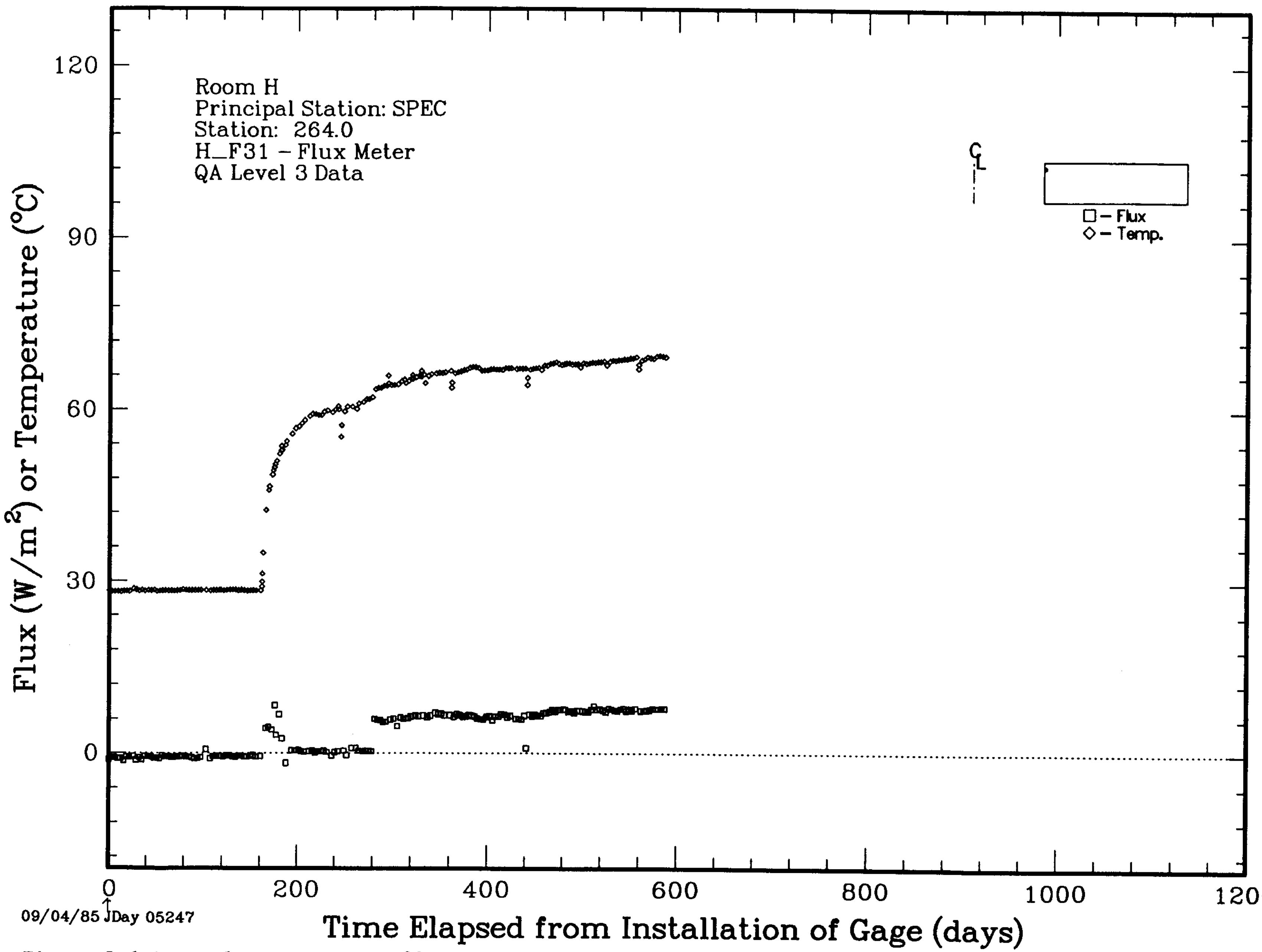

Figure 5.6.1c. Flux Meters, H F31

Table 5.6.1d. Flux Meters, H F32

Gage: H_F32

****

***** H_F32 PI Comments *****

09/24/87 DLH [RANK = 8(1),9(2)] THE FLUX DATA SUFFER FROM SOME SCATTER. THE SAME INSULATION PROBLEMS INFLUENCED THIS GAGE ALSO. THE INSULATION PROBLEM WAS SOLVED ON DAY 279. [COMPRESSION = 12.39:1] (DEM)

***** H_F32 Location *****

Principal Station SPEC
Station 264.2

				Gage Coordinates											
								Prin Stat		Room					
Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Z1 (m)	Z2 (m)	Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F32-1	TPL	P REM	H	5.63	5.53	264.16	264.15	0.42	0.42	0.31	0.31	RDF	08/27/85	25-5753A#0	X+0.101Y+0.995Z 0.000
H_F32-2	TC	P REM	H	5.63	5.53	264.16	264.15	0.42	0.42	0.31	0.31	RDF	08/27/85	25-5753A#0	

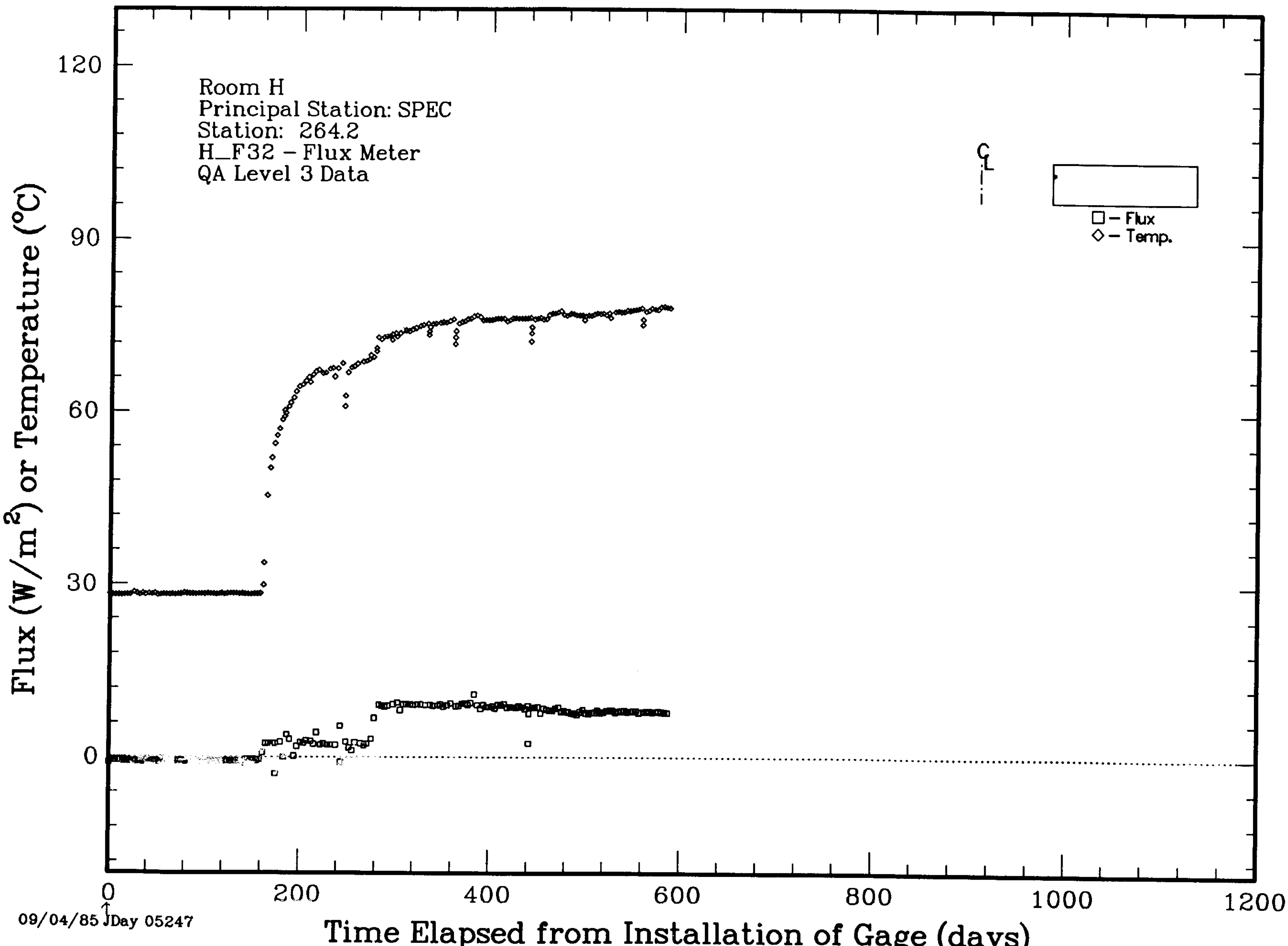

Figure 5.6.1d. Flux Meters, H F32

Table 5.6.1e. Flux Meters, H F33

Gage: H_F33

****

***** H_F33 PI Comments *****

09/24/87 DLH [RANK = 9(1),9(2)] THE DATA ARE EXCEPTIONAL FOR THE UNIT. AGAIN, THE INSULATION BLANKET AND HEATER ELEMENT SHIFTS ACCOUNT FOR THE FLUX RESPONSE, AND THIS WAS CORRECTED ON DAY 279; HOWEVER, THIS GAGE WAS NOT AFFECTED AS MUCH AS SOME OF THE OTHER GAGES. [COMPRESSION = 12.31:1] (DEM)

***** H_F33 Location *****

Principal Station SPEC
Station 264.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F33-1	TPL	P REM	H	5.66	5.57	264.00	264.00	-0.19	-0.19	-0.30	-0.30	RDF	08/27/85	25-5753A#0	X+0.104Y+0.994Z 0.000
H_F33-2	TC	P REM	H	5.66	5.57	264.00	264.00	-0.19	-0.19	-0.30	-0.30	RDF	08/27/85	25-5753A#0	

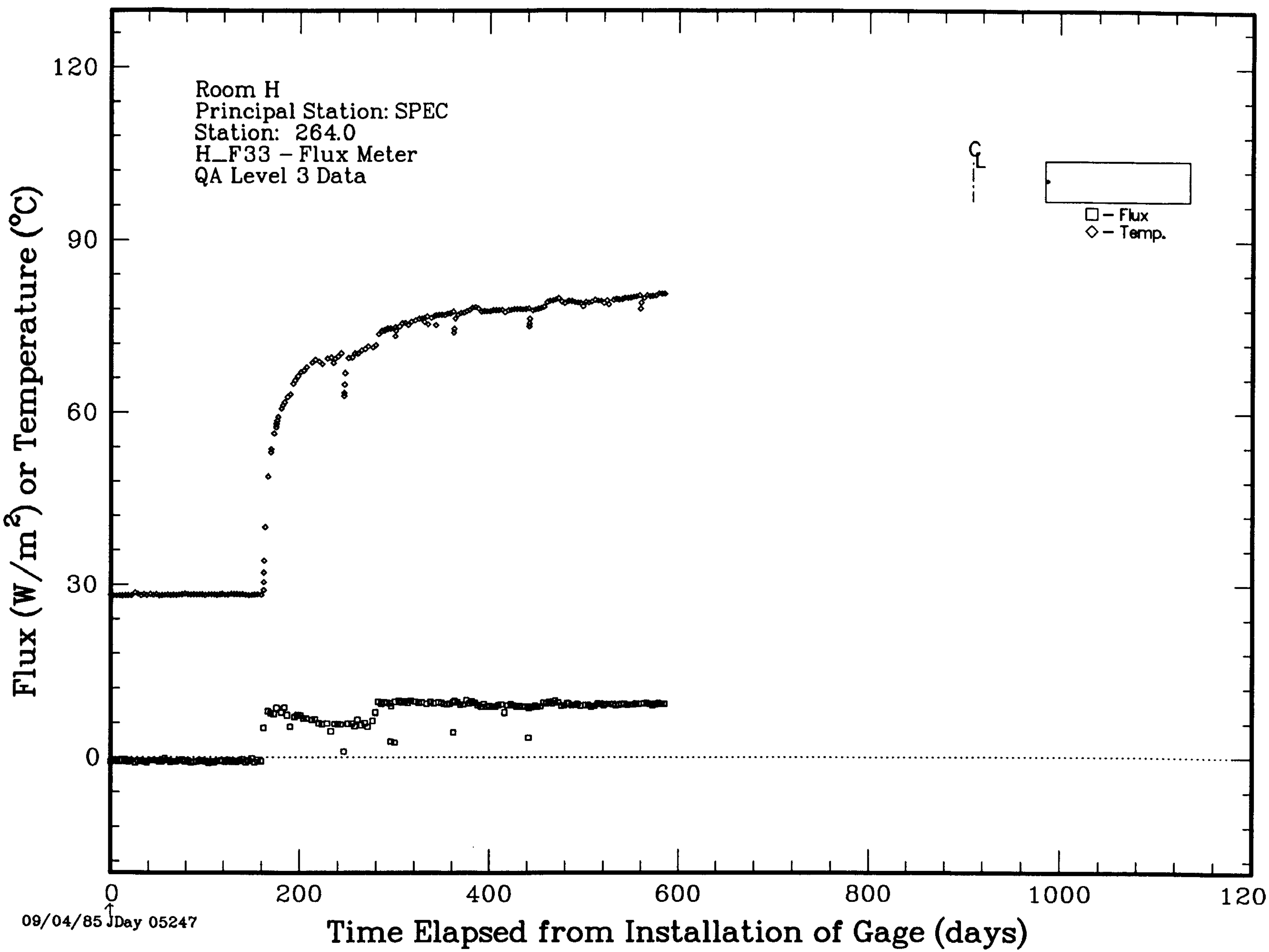

Figure 5.6.1e. Flux Meters, H F33

Table 5.6.1f. Flux Meters, H F34

Gage: H_F34

****

***** H_F34 PI Comments *****

09/24/87 DLH [RANK = 9(1),9(2)] THE DATA OF THE UNIT ARE EXCEPTIONAL. AS WITH THE OTHER GAGES, THE INFLUENCE OF THE INSULATION BLANKET PROBLEM IS VERY CLEAR; THIS WAS CORRECTED ON DAY 279. A SMALL CHANGE IN FLUX DATA IS FOUND ON DAY 454 WHEN A OPTICAL SURVEY OF GAGE LOCATIONS WAS MADE. THE SURVEY AFFECTED SOME GAGES MORE THAN OTHERS. THE AFFECT ON GAGE 1 OF THIS UNIT WAS QUITE DISTINCT. PROBABLY A HEATER ELEMENT WAS SHIFTED DURING THE PROCESS OR THE INSULATION WAS REAPPLIED DIFFERENTLY THAN BEFORE. [COMPRESSION = 11.43:1] (DEM)

***** H_F34 Location *****

Principal Station SPEC
Station 264.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F34-1	TPL	P REM	H	5.66	5.45	264.00	263.99	-0.19	-0.19	-0.30	-0.30	RDF	08/27/85	25-5753A#0	X+0.104Y+0.994Z 0.000
H_F34-2	TC	P REM	H	5.66	5.45	264.00	263.99	-0.19	-0.19	-0.30	-0.30	RDF	08/27/85	25-5753A#0	

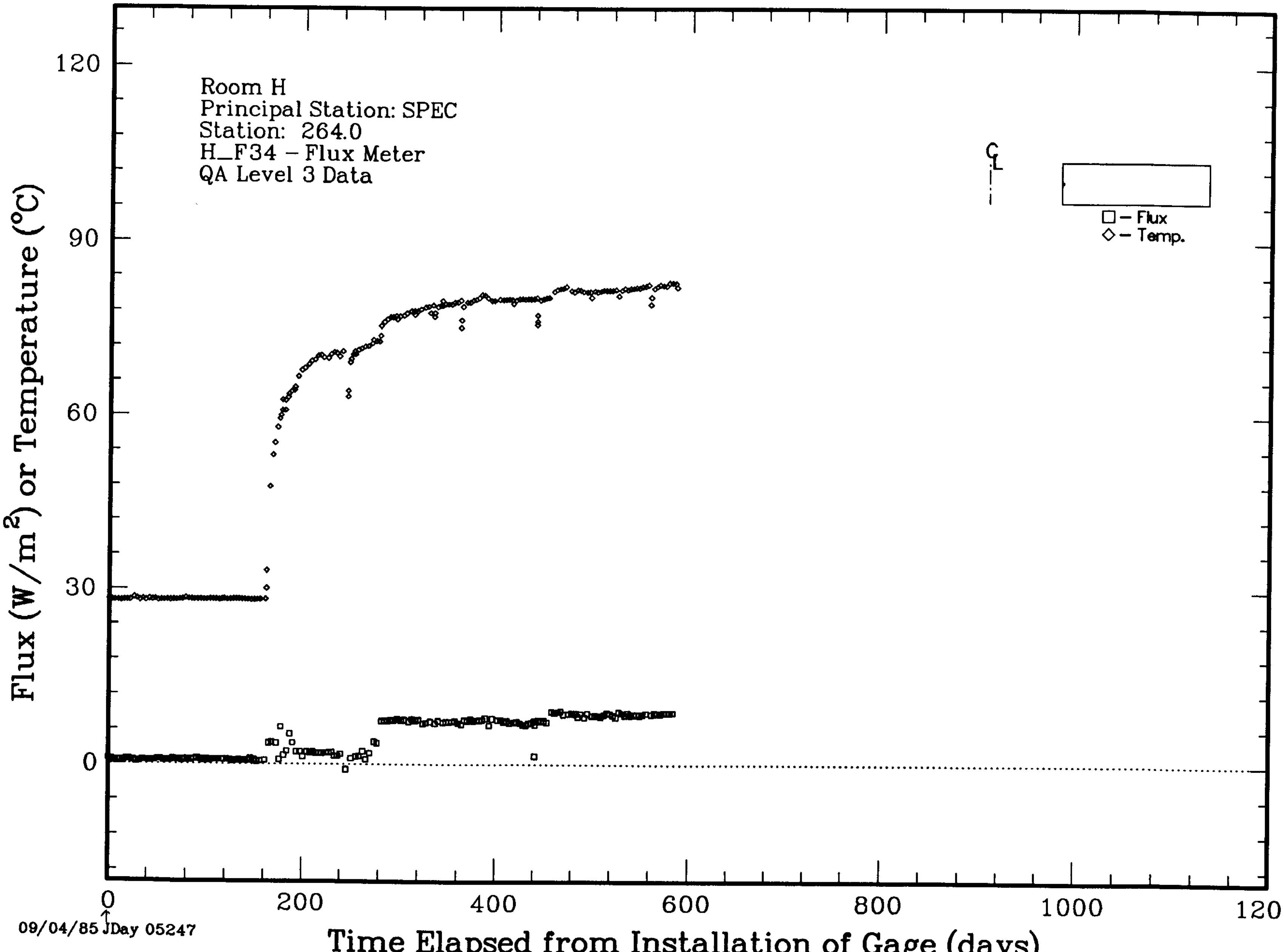

Figure 5.6.1f. Flux Meters, H F34

Table 5.6.1g. Flux Meters, H F35

Gage: H_F35

****

***** H_F35 PI Comments *****

09/24/87 DLH [RANK = 8(1),8(2)] THE DATA OF THIS UNIT SHOW SOMEWHAT GREATER SCATTER, FOR UNKNOWN REASONS, WHICH LOWERED THE RANKING. THE SAME AFFECTS NOTED FOR THE OTHER FLUX METERS ARE OBSERVED ON THIS UNIT. AGAIN CORRECTION OCCURRED ON DAY 279. [COMPRESSION = 11.74:1] (DEM)

***** H_F35 Location *****

Principal Station SPEC
Station 263.9

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F35-1	TPL	P REM	H	5.67	5.58	263.89	263.89	-0.59	-0.59	-0.70	-0.70	RDF	08/27/85	25-5753A#0	X+0.106Y+0.994Z 0.000
H_F35-2	TC	P REM	H	5.67	5.58	263.89	263.89	-0.59	-0.59	-0.70	-0.70	RDF	08/27/85	25-5753A#0	

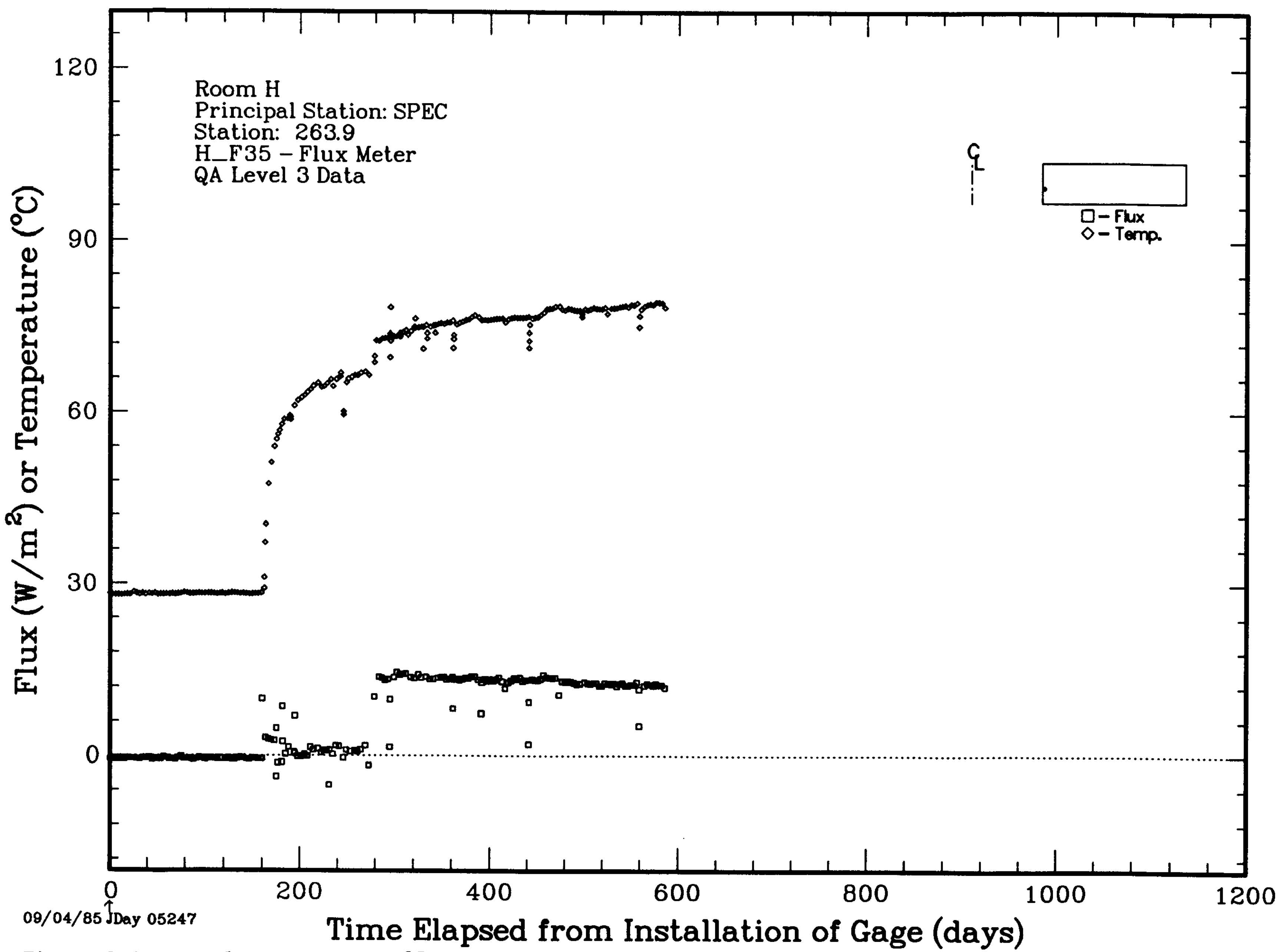

Figure 5.6.1g. Flux Meters, H F35

Table 5.6.1h. Flux Meters, H F36

Gage: H_F36

****

***** H_F36 PI Comments *****

09/24/87 DLH [RANK = 6(1),8(2)] THE DATA OF THE UNIT SHOW SOME SCATTER FOR UNKNOWN REASONS. THE SCATTER IN THE FLUX DATA IS VERY PRONOUNCED AS SHOWN BY THE LOW RANK. THE SCATTER PROBLEM OCCURRED AFTER DAY 434, WITH HIGH QUALITY DATA BEFORE THAT DATE. AGAIN THE UNIT SUFFERS FROM THE INSULATION PROBLEM, WHICH WAS CORRECTED ON DAY 279. THE OPTICAL HOLE SURVEY ON DAY 454 REALLY PRODUCED A MARKED INFLUENCE ON THE FLUX METER DATA OF GAGE 1 AND EVEN AN AFFECT ON THE TEMPERATURE DATA OF GAGE 2. PERHAPS A HEATER ELEMENT WAS MOVED ONTO THE UNIT. [COMPRESSION = 4.05] (DEM)

***** H_F36 Location *****

Principal Station SPEC
Station 264.2

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_F36-1	TPL	P REM	H	5.65	5.57	264.18	264.19	-1.25	-1.25	-1.36	-1.36	RDF	08/27/85	25-5753A#0	X+0.101Y+0.995Z 0.000
H_F36-2	TC	P REM	H	5.65	5.57	264.18	264.19	-1.25	-1.25	-1.36	-1.36	RDF	08/27/85	25-5753A#0	

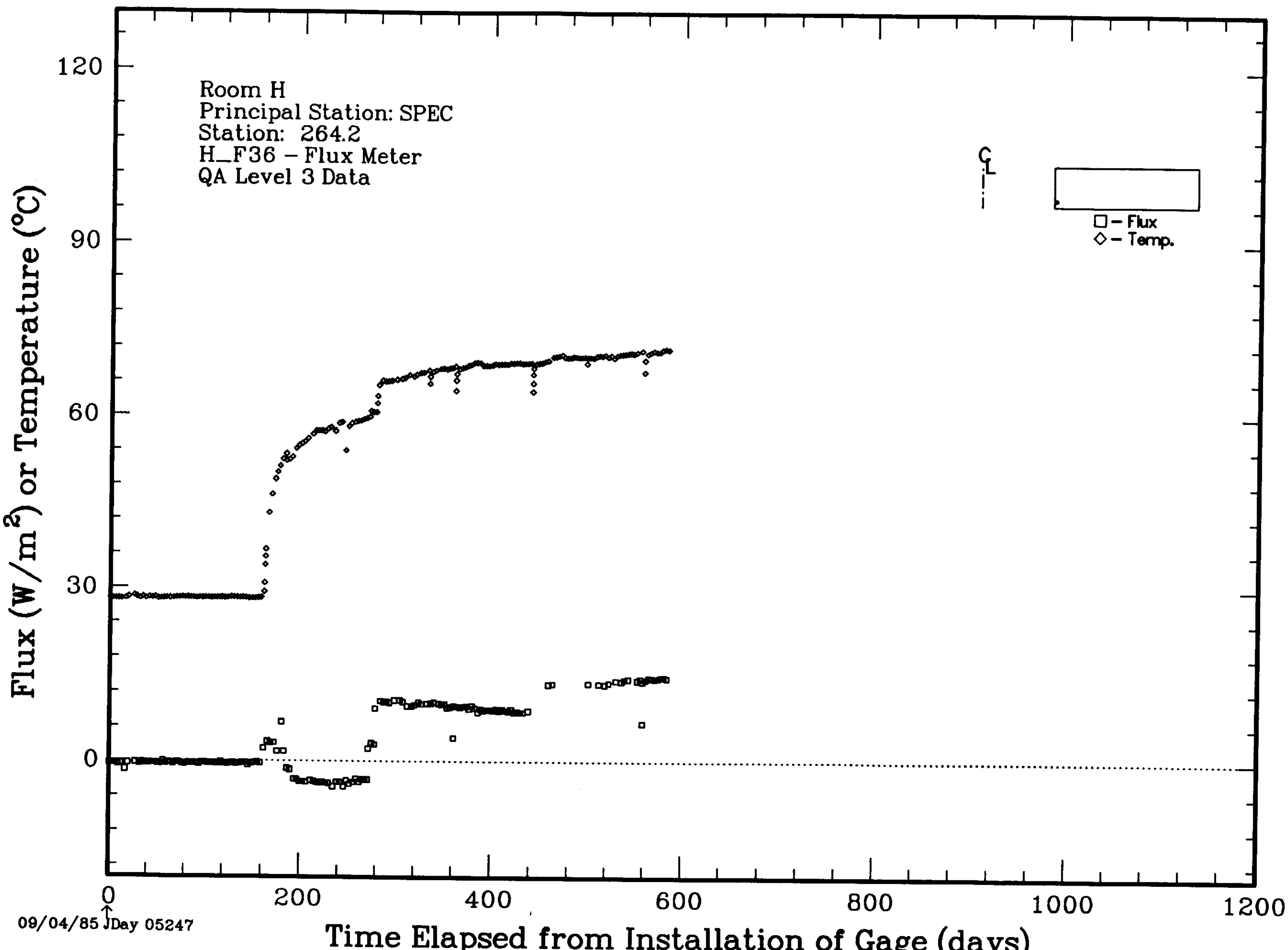

Figure 5.6.1h. Flux Meters, H F36

5.7 Heater Power Measurements

Pillar heating was monitored by meters in the power supplies to panels of heating tapes. Each panel contained 8 heating tapes, except for the last panel, which contained 13 heating tapes. Changes during construction in the power distribution system resulted in elimination of half of the planned power gages. In this arrangement, each power meter monitored the combined power of two panels, except in the case of the last panel, which had an individual power meter. Consequently, only odd-numbered gages appear in the results. The first panel begins at a room coordinate of T = 0^o, with subsequent panels progressing counterclockwise around the pillar. The first of the two panel segments are monitored by gage H 021 and the last panel segment by gage H 039.

Heater power results are given in Tables 6.7.1a-j and Figures 6.7.1a-j.

Because of the uncertainties of the values obtained from the current viewing resistor, power measurements have a large scatter, as is apparent in the power results presented here. The mean of the data represents quite adequately the power supplied to the heaters.

Several features of the records need explanation. A routine, periodic evaluation and manual adjustment of power was used to regulate heat input to the pillar. These periodic adjustments consisted of changes in voltage supplied to the 19 individual panels. Except for one panel containing 13 heater tapes on an individual Variac, the panels of 8 heater tapes each were controlled in groups of two by a shared Variac. The method of control caused a discrete change in the power level, whose magnitude varied with panel group.

The few data points that are well off the mean values are the results of heater outages for maintenance or renovation of local power systems. General power outages, while apparent in the temperature records, will not appear in the power records.

In an exact analysis of the test, the integrated power input to the heaters must be used to calculate the heat flux values. Meanwhile, we can determine a crude average power input to the experiment and compare this to the requested value. Simple graphical averaging of the data suggests that the average heater power is close to 1420 W for each of the nine double panel segments (16 heater tapes), and 1200 W for the H 039 single panel (13 heater tapes). Based on this, measured heat flux is 133.1 W/m^2 (12.36 W/ft^2), which is not too much different (2%) from the requested value of 135 W/m^2.

Only a full analysis of the experiment can determine the fraction of the heat or power that goes into the pillar compared to the heat lost through the insulation.

Further, while the estimates of heat loss through the insulated room entry door are currently considered small, this potential loss mechanism must be considered in any analysis. A potential source of heat, the room lights, are turned on only as necessary for room maintenance.

Table 5.4.1a. Heater Power Gage, H 021

Gage: H_021

****

***** H_021 PI Comments *****

09/25/87 DLH [RANK = 10] THE NORMAL TOLERANCE OF THE DATA IS +/- 75W (5%), WHICH ACCOUNTS FOR NEARLY ALL THE APPARENT SCATTER. POINTS SCATTERED MORE THAN THE +/- 100W HAVE BEEN DELETED. THERE WERE TWO MAJOR ADJUSTMENTS IN VARIAC SETTINGS THAT OCCURRED BETWEEN DAYS 58 AND 63 (JDAY 6101 TO 6106) AND BETWEEN DAYS 364 AND 365 (JDAY 7042 TO 7043), WITH THE FORMER ADJUSTMENT PRODUCING THE CHANGE IN DATA. THE MAINTENANCE SCHEDULE CALLED FOR "MINOR" ADJUSTMENTS ON A REGULAR SCHEDULE, WHICH ACCOUNTS FOR THE ADJUSTMENTS ON INDIVIDUAL HEATER SEGMENTS; SOME OF WHICH ARE APPRECIABLE IN MAGNITUDE. [COMPRESSION = 1.00:1] (DEM)

***** H_021 Location *****

Principal Station SPEC
Station 90.0

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_021-0	HTR	P REM	V	5.49	5.49	90.00	108.34	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

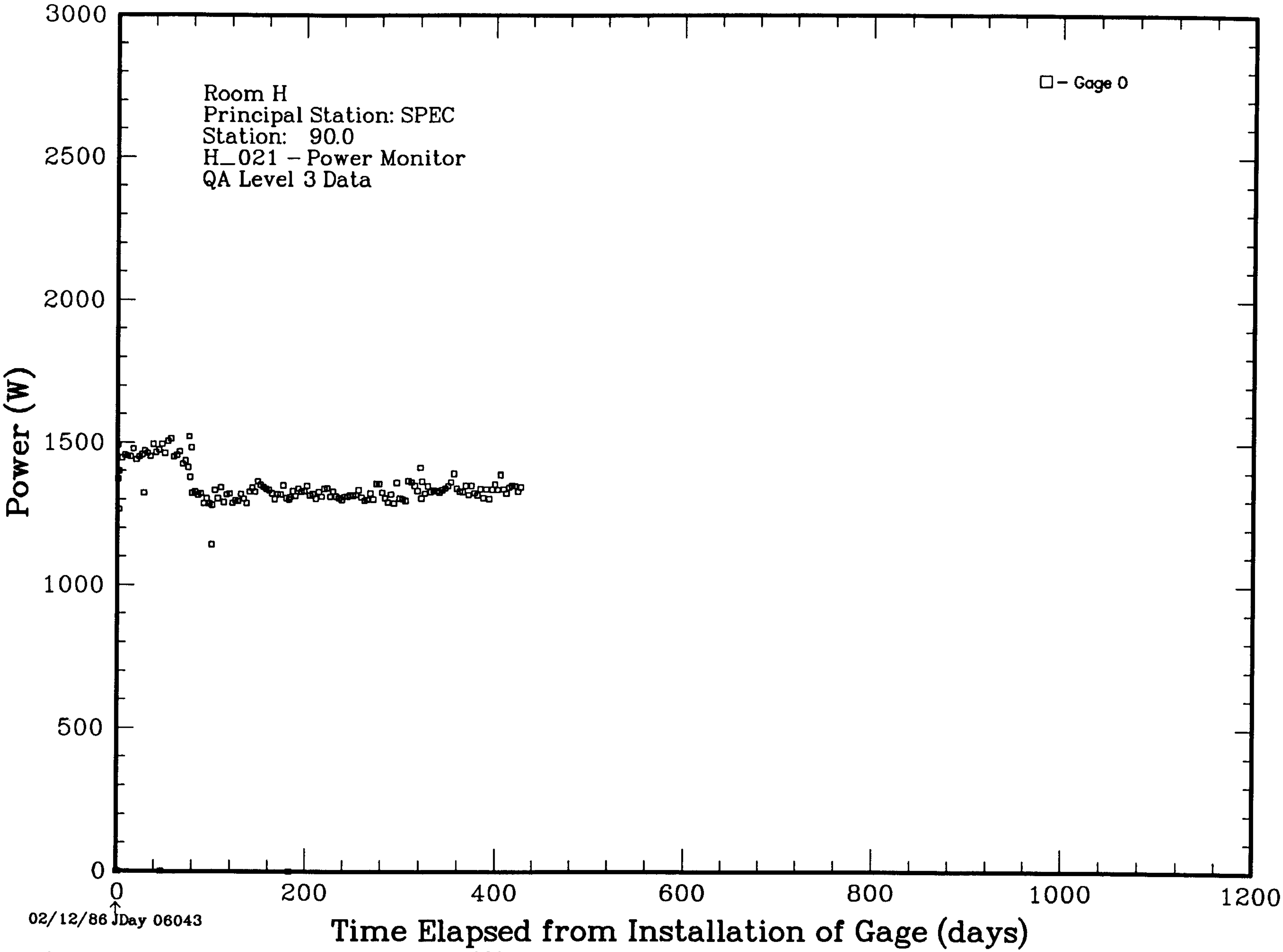

Figure 5.7.1a. Heater Power Gage, H 021

Table 5.4.1b. Heater Power Gage, H 023

Gage: H_023

****

***** H_023 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0 [COMPRESSION = 1.00:1]
(DEM)

***** H_023 Location *****

Principal Station SPEC
Station 126.7

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_023-0	HTR	P REM	V	5.49	5.49	126.69	145.03	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

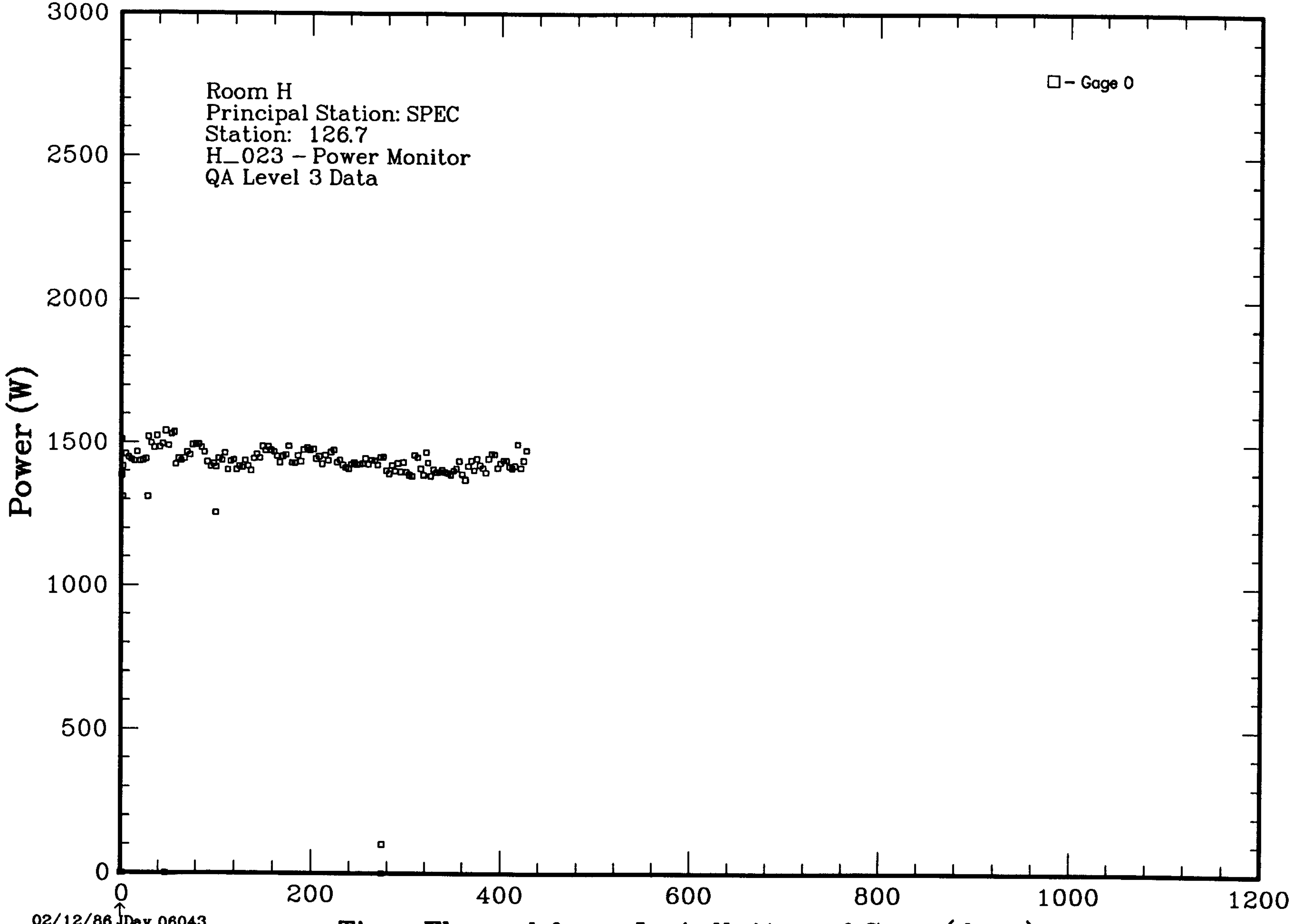

Figure 5.7.1b. Heater Power Gage, H 023

Table 5.4.1c. Heater Power Gage, H 025

Gage: H_025

****

***** H_025 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION 1.00:1]
(DEM)

***** H_025 Location *****

Principal Station SPEC
Station 163.4

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_025-0	HTR	P REM	V	5.49	5.49	163.38	181.72	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

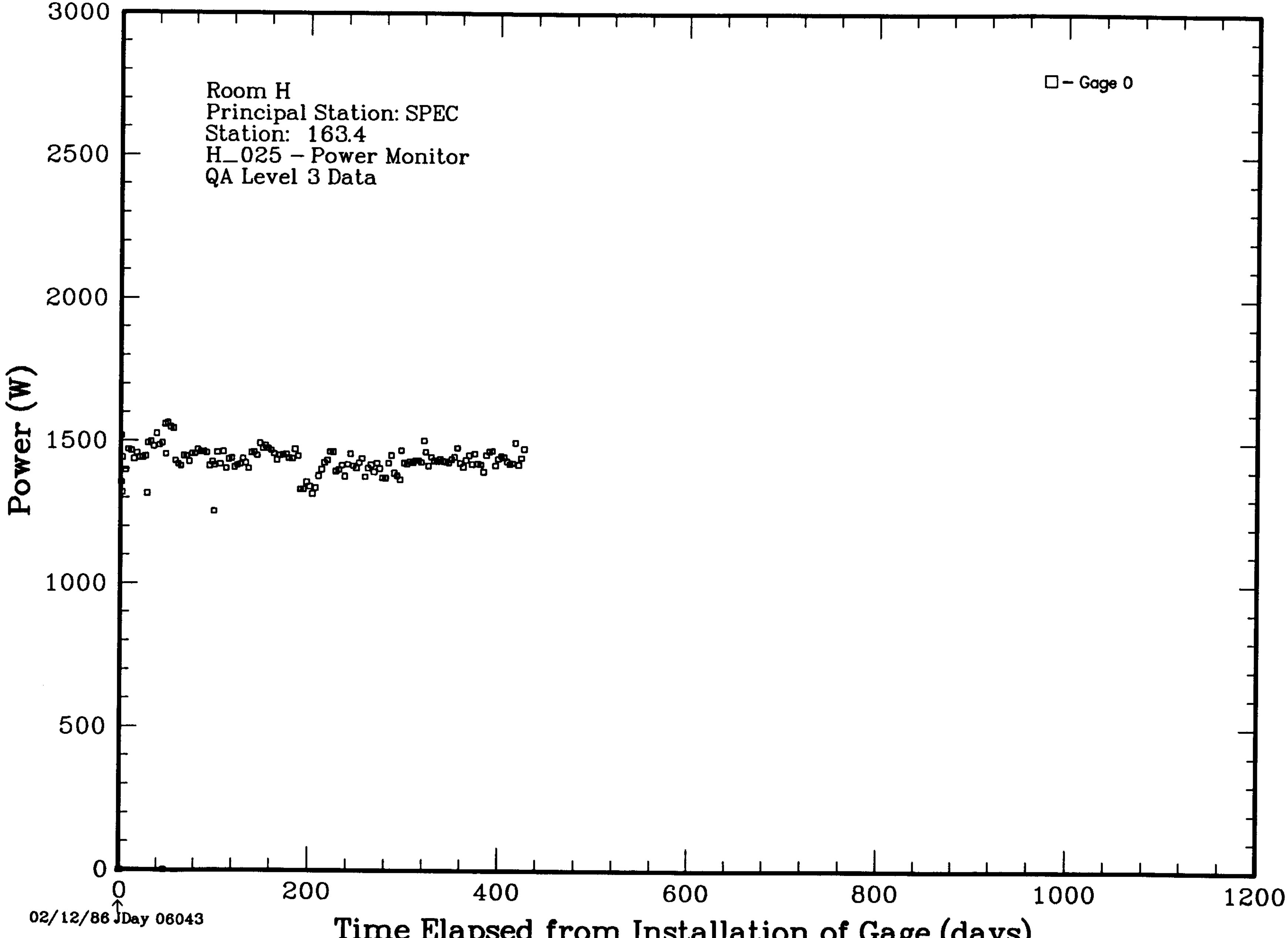

Figure 5.7.1c. Heater Power Gage, H 025

Table 5.4.1d. Heater Power Gage, H 027

Gage: H_027

****

***** H_027 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION 1.00:1]
(DEM)

***** H_027 Location *****

Principal Station SPEC
Station 200.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_027-0	HTR	P REM	V	5.49	5.49	200.06	218.41	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

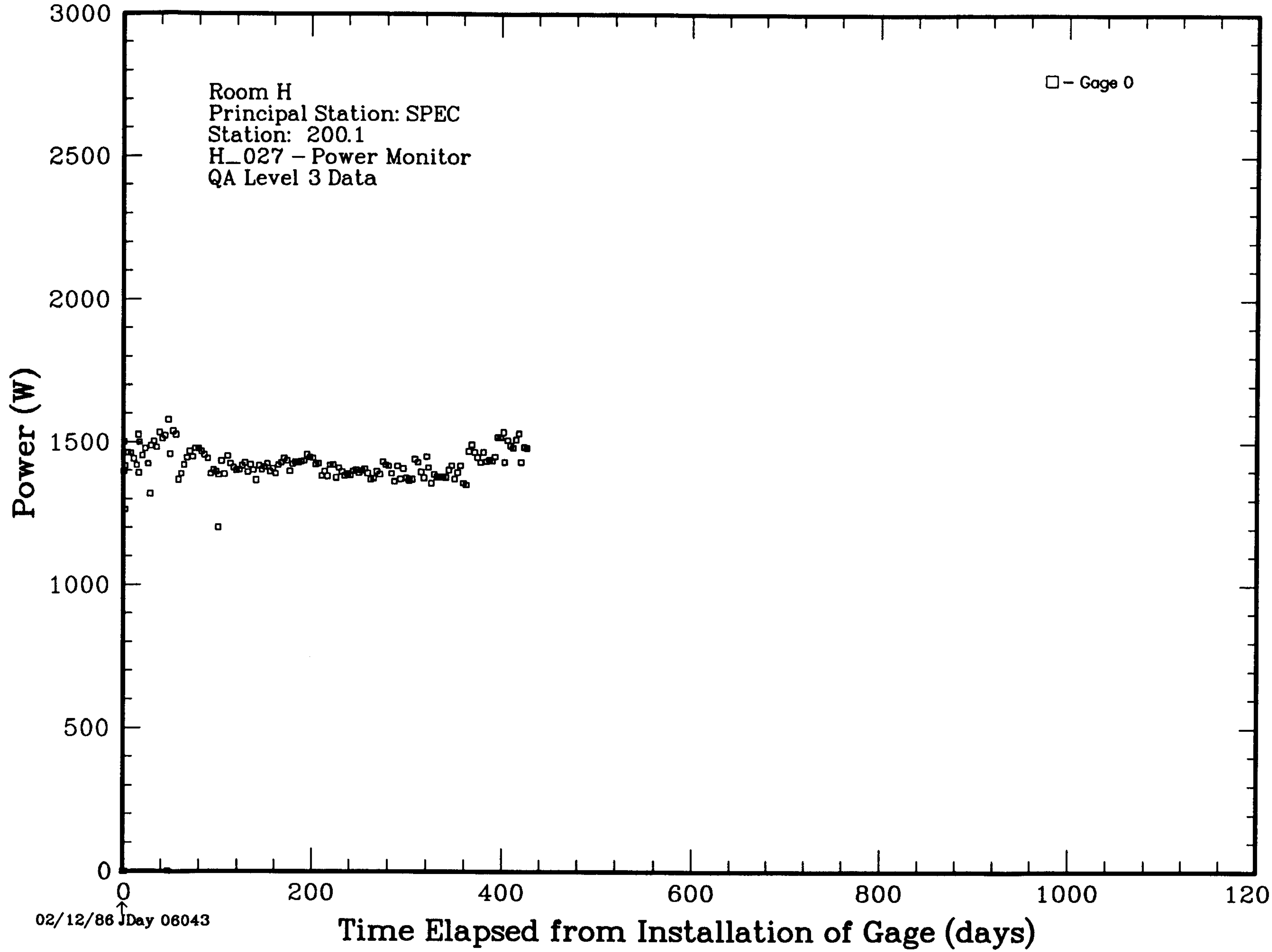

Figure 5.7.1d. Heater Power Gage, H 027

Table 5.4.1e. Heater Power Gage, H 029

Gage: H_029

****

***** H_029 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION = 1.00:1]
(DEM)

***** H_029 Location *****

Principal Station SPEC
Station 236.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Z2 (m)	Room Z1 (m)	Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_029-0	HTR	P REM	V	5.49	5.49	236.75	255.09	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

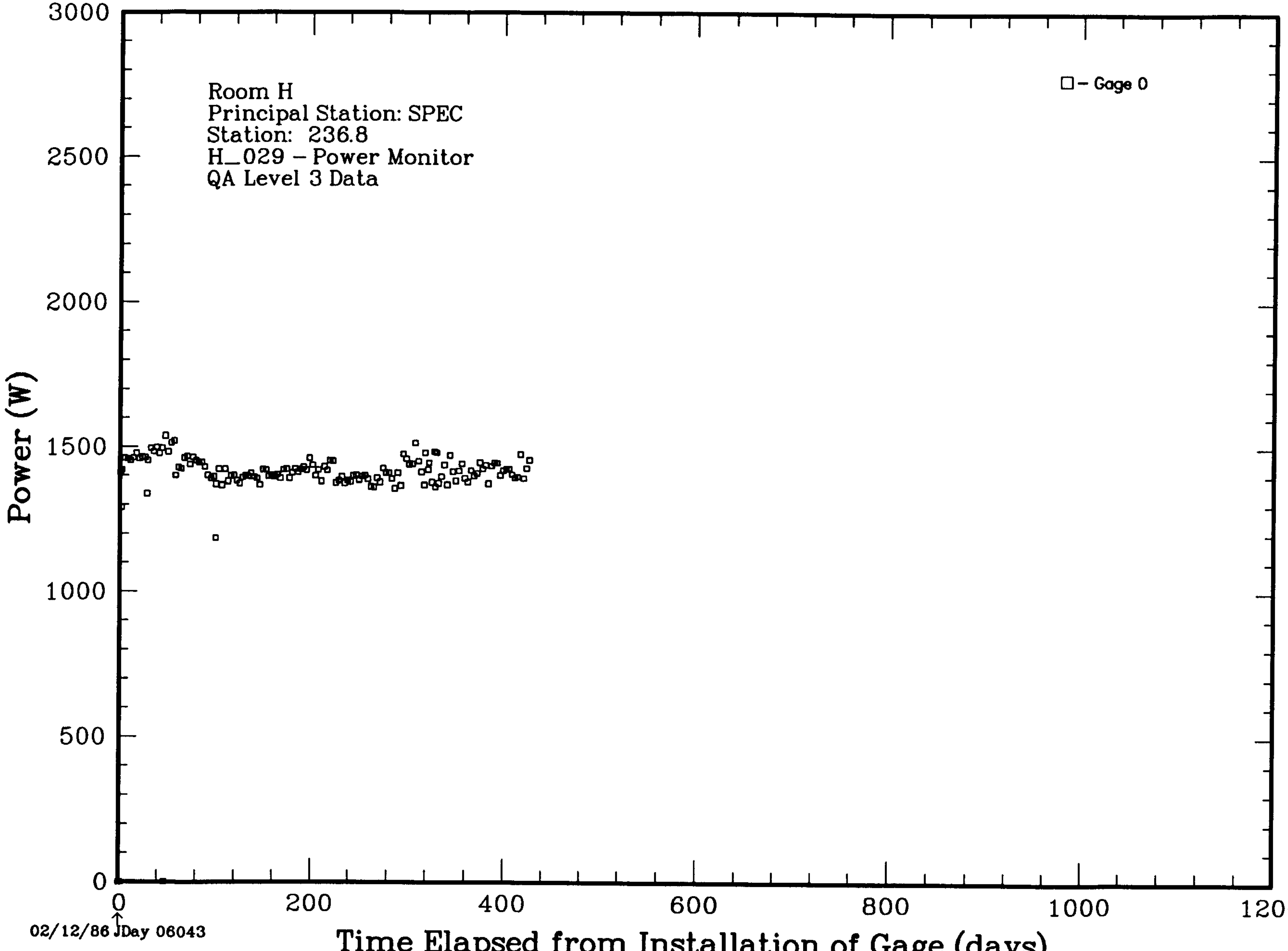

Figure 5.7.1e. Heater Power Gage, H 029

Table 5.4.1f. Heater Power Gage, H 031

Gage: H_031

****

***** H_031 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION = 1.00:1]
(DEM)

***** H_031 Location *****

Principal Station SPEC
Station 273.4

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_031-0	HTR	P REM	V	5.49	5.49	273.44	291.78	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

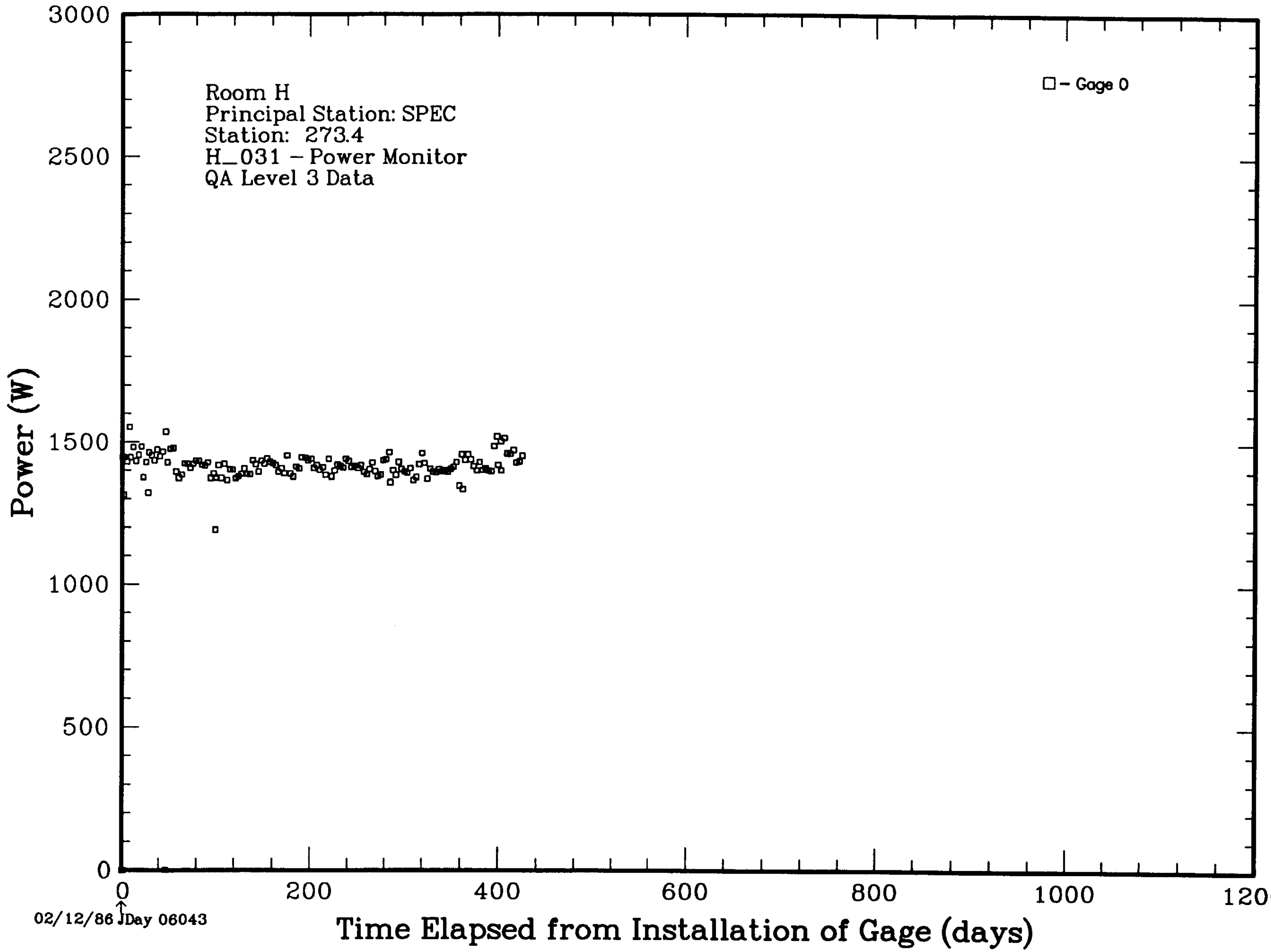

Figure 5.7.1f. Heater Power Gage, H 031

Table 5.4.1g. Heater Power Gage, H 033

Gage: H_033

****

***** H_033 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION = 1.00:1]
(DEM)

***** H_033 Location *****

Principal Station SPEC
Station 310.1

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_033-0	HTR	P REM	V	5.49	5.49	310.13	328.47	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

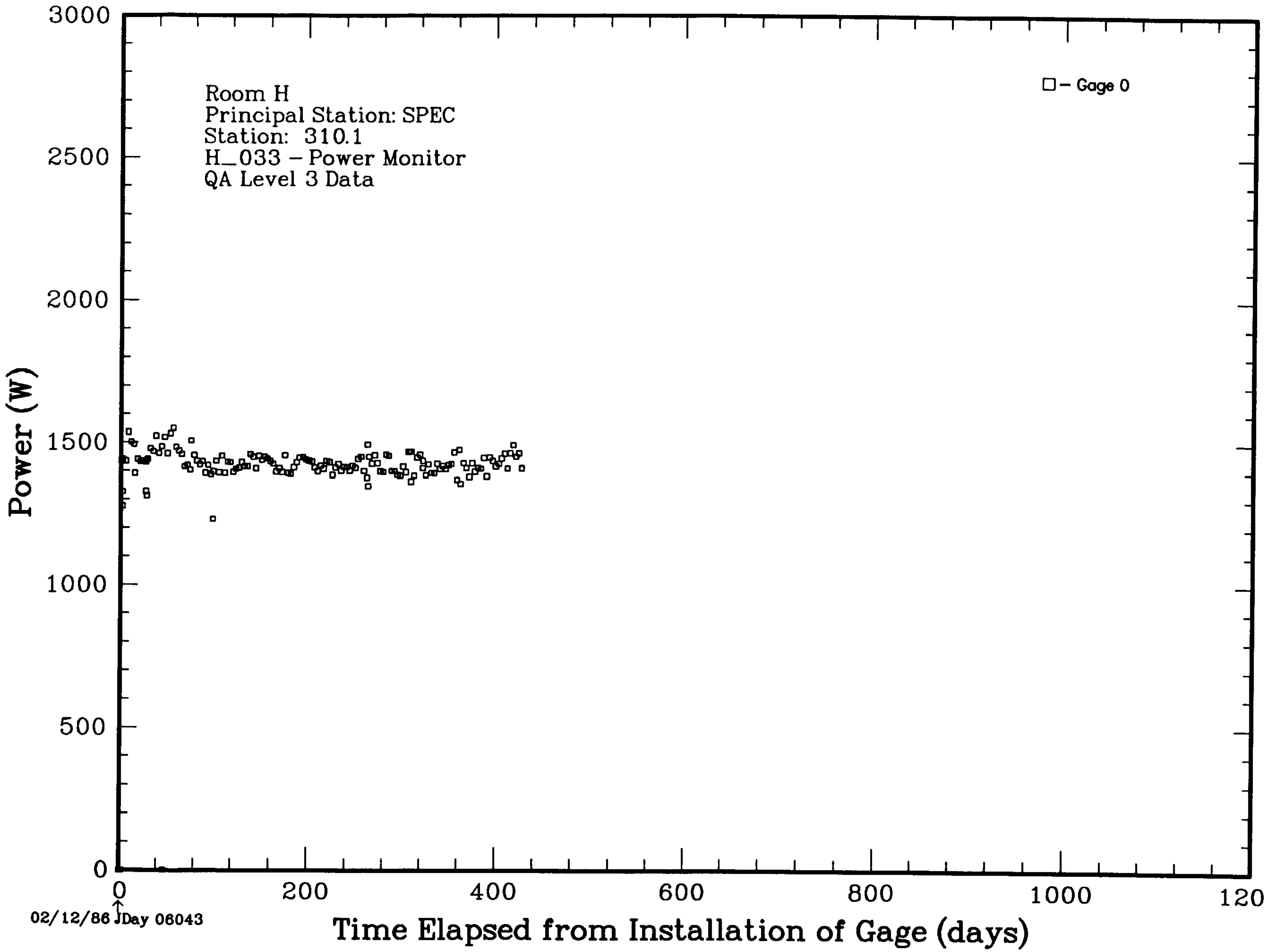

Figure 5.7.1g. Heater Power Gage, H 033

Table 5.4.1h. Heater Power Gage, H 035

Gage: H_035

****

***** H_035 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION = 1.00:1]
(DEM)

***** H_035 Location *****

Principal Station SPEC
Station 346.8

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_035-0	HTR P	REM	V	5.49	5.49	346.81	5.16	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

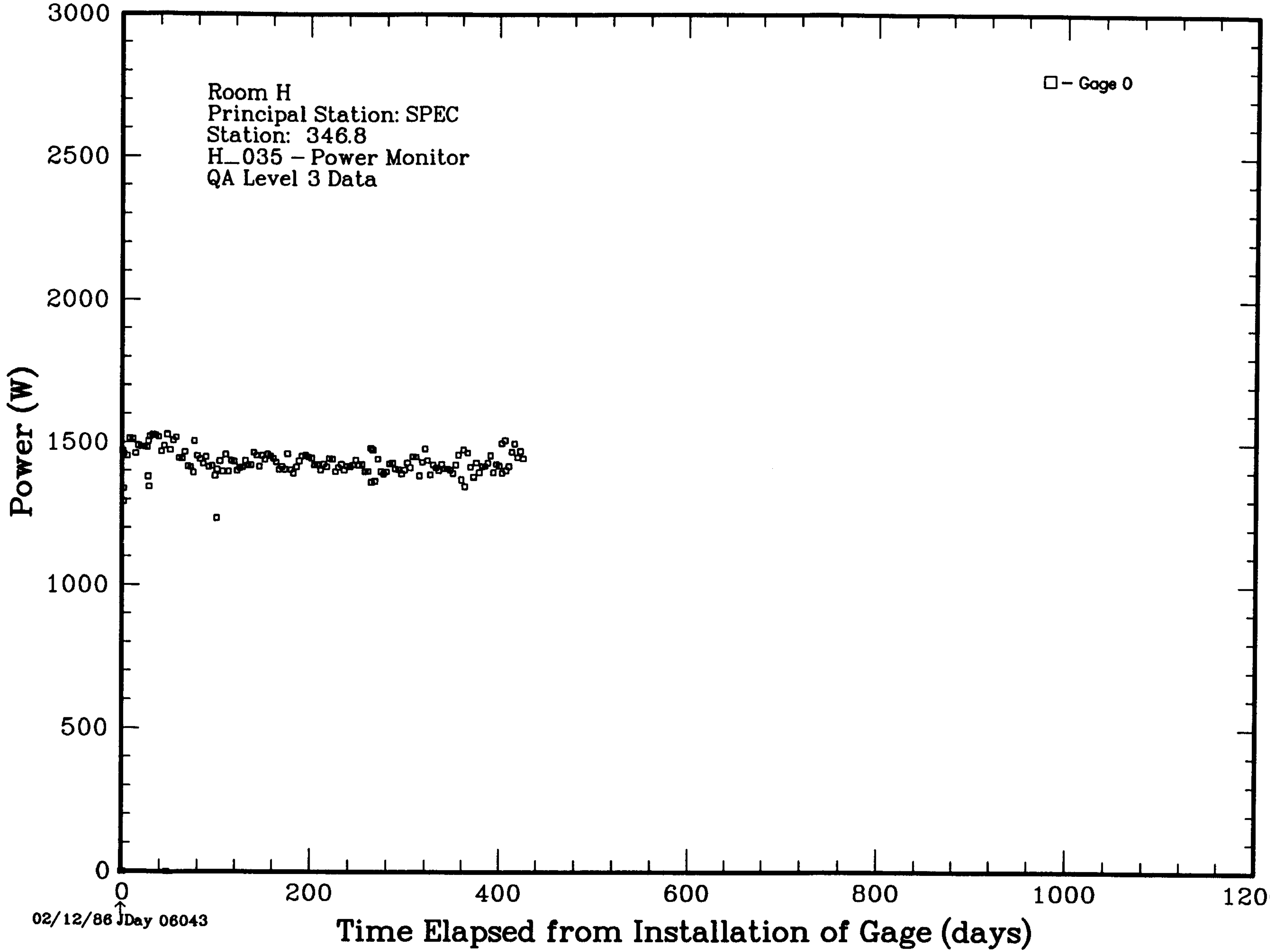

Figure 5.7.1h. Heater Power Gage, H 035

Table 5.4.1i. Heater Power Gage, H 037

Gage: H_037

****

***** H_037 PI Comments *****

09/25/87 DLH [RANK = 10] SEE COMMENTS ON GAGE H_021-0. [COMPRESSION = 1.00:1]
(DEM)

***** H_037 Location *****

Principal Station SPEC
Station 23.5

Gage Number	Gage Type	Rec	Dir	R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Gage Coordinates Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_037-0	HTR	P	REM V	5.49	5.49	23.50	41.85	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

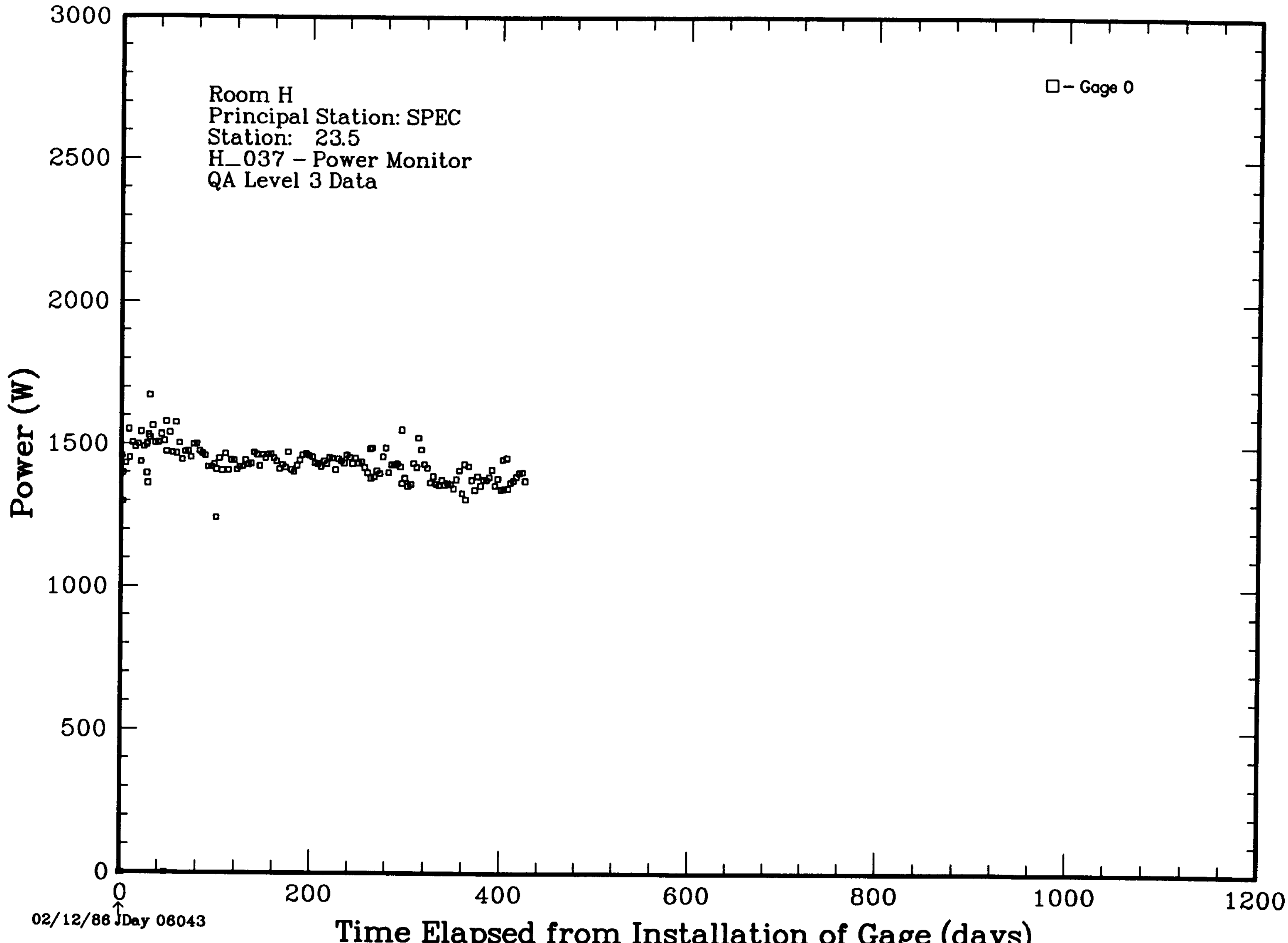

Figure 5.7.1i. Heater Power Gage, H 037

Table 5.4.1j. Heater Power Gage, H 039

Gage: H_039

****

***** H_039 PI Comments *****

9/25/87 DLH [RANK = 10] THIS WAS A SINGLE HEATER PANEL GAGE. ALSO, SEE COMMENTS ON GAGE H_021-1. [COMPRESSION = 1.00:1] (DEM)

***** H_039 Location *****

Principal Station SPEC
Station 60.2

Gage Number	Gage Type	Rec	Dir	Gage Coordinates R1 (m)	R2 (m)	T1 (deg)	T2 (deg)	Prin Stat Z1 (m)	Prin Stat Z2 (m)	Room Z1 (m)	Room Z2 (m)	Gage Manuf	Inst Date	PO Item	Comments
H_039-0	HTR	P REM	V	5.49	5.49	60.19	90.00	-1.52	1.52	-1.52	1.52	BRISCOE	06/03/85	48-8230#01	

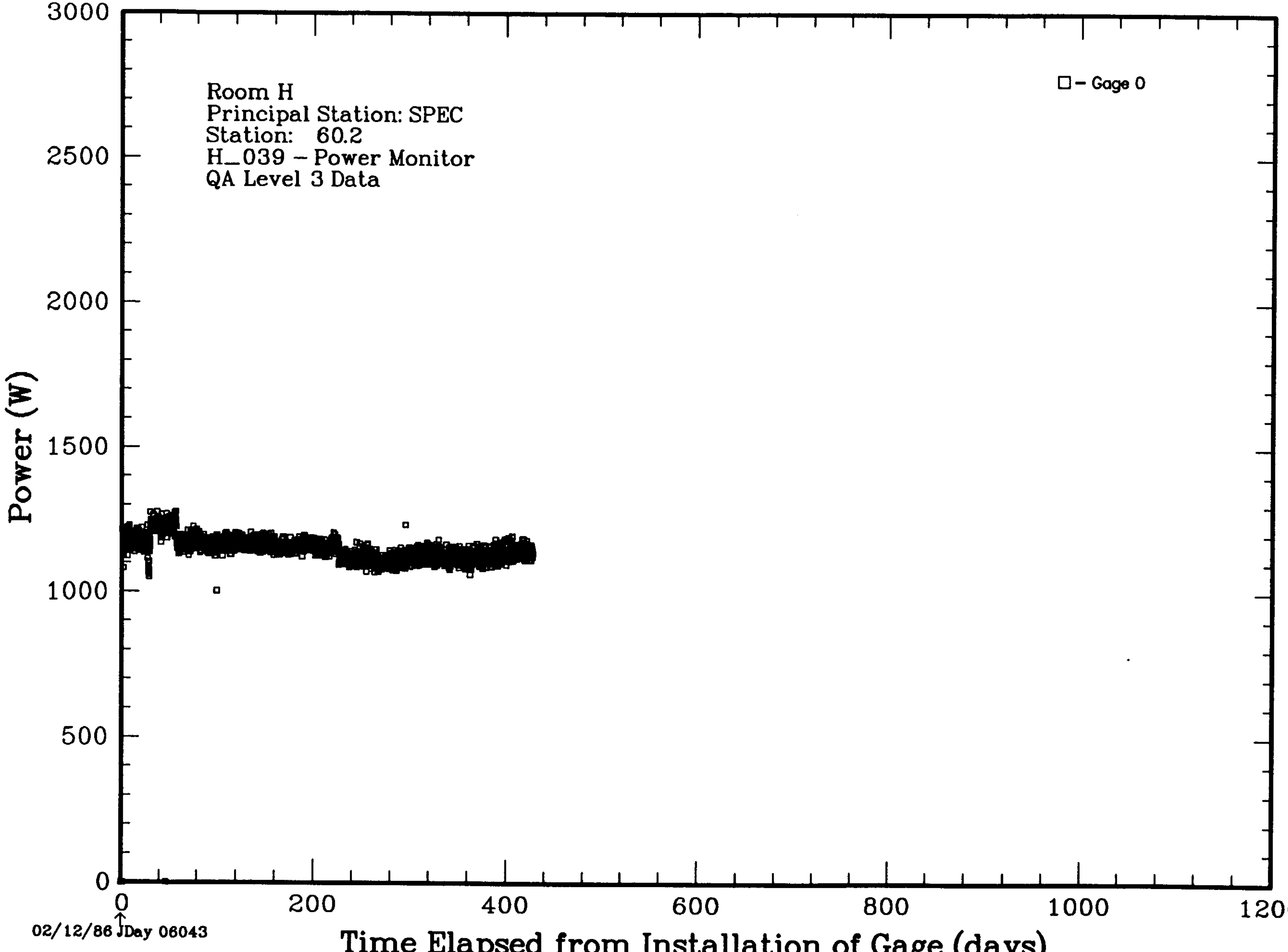

Figure 5.7.1j. Heater Power Gage, H 039

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6 INTERPRETATION AIDS

Interpretation of in situ test data from the TSI tests involves some interesting, but often ignored or unrecognized, factors arising from the time-dependent response of the salt. These important factors must be understood before undertaking any meaningful analysis of the in situ data. Ignoring the factors may contribute to failure of the analyses used to predict the observed in situ behavior, and certainly causes confusion in interpretation of numerical studies.

Analysts have a marked tendency to take in situ data at face value. The analyst must realize that in situ data represent only part of (1) the displacements that occur during the mining of an opening, and (2) the stress histories that are induced around the mined opening. Even for the observed temperatures, the mined opening and underground operations activity can influence the observed values. Often the in situ test investigator and the analyst may think that nothing has happened before we arrived and started to make measurements. However, significant events can and often do occur before gage installation and beginning of measurement. Proper interpretation requires that the in situ test investigators recognize both the need to minimize "lost" or "unmeasured" displacements insofar as possible in the measurements, and to recognize the influence of fielding activity on both stress and temperature measurements. In turn, the numerical analyst must recognize the consequences of typical model abstractions and accepted assumptions, such as instantaneous excavation, introduced more or less routinely into the calculations, which may not be permissible for actual in situ conditions and the detailed configuration of gages.

In obtaining the displacement results presented in this report, we took every care to reduce the "lost" displacements to the smallest possible quantity. Further, the interpretation recognizes where the lost displacements reside. Schematically, the salt displacements for both closures and extensometers can be reconstructed (in terms of following the trajectory of a material point in the salt) as a mining face of an opening approaches, passes, and recedes from the plane of the point. If the face velocity is constant, the points will move in time according to the constitutive laws for the creep of salt. (A nonconstant face velocity introduces an additional pseudo time-dependent term.) This situation can be illustrated. In the Figure 6.0.1, two material points, E and C, represent an extensometer and closure point, respectively. Trajectory lines for vertical displacements are drawn through the two points. For both points E and C, the points undergo displacements before the mining face reaches them. Although these displacements are in general 3-D, we show here the vertical component of the displacement field because only this component influences the vertical closure and extensometer results. Displacements of this type are the result of the far-field, stress-strain influence of the opening on the surrounding salt. Measurement of these displacements can be obtained only through very special experimental efforts, and they usually are unrecognized. Notice that point C actually starts above the eventual line of the opening, but the displacement brings the point down to become a surface point as the face approaches the plane of the point. Point displacements in advance of the mining face cannot be measured at the face, even quickly, because the mining operation essentially mines out the displaced material. After the mining face has

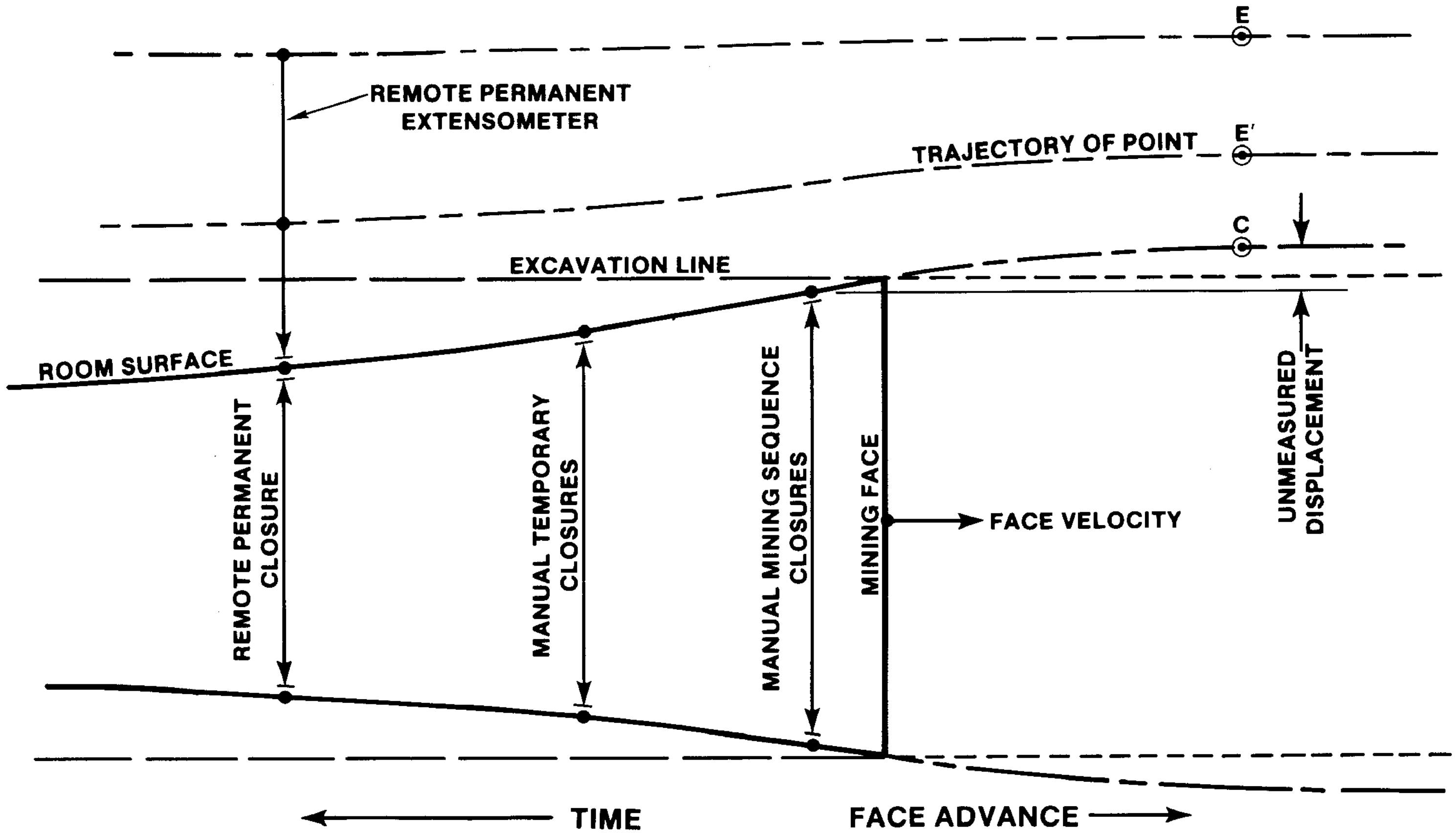

Figure 6.0.1. Particle Trajectories for Displacements During Mining

passed, both points E and C continue to displace with time. However, now the investigator potentially has access to these points and can install instruments to measure their displacements. Recall that the points continue to displace from creep, even though the advance of the face may stop or hesitate. Gage installation can be represented on the trajectory curves of the points. At the WIPP, the early-mining-sequence closure gages were installed within about 1 m of the mining face, and within less than 1 hour of opening the intended gage station. This is noted on the trajectory curve of the surface point C. As operations permitted, the mining-sequence gages were supplemented by the temporary closure gages, as shown. Again, as operations and hole drilling permitted, the permanent closure stations were established and, for the first time, permanent extensometers were installed. It is clear that the delayed access for installation of the extensometer gage results in a significant "lost" displacement, as shown in the trajectory for point E.

Recognition of the events explained above permits an abstract reconstruction of measured and "unmeasured" displacements. Such reconstructions are illustrated for closure measurements in Figure 6.0.2, and for extensometer measurements in Figure 6.0.3. Figure 6.0.3 includes an intermediate extensometer point E'and also shows its treatment. It is often difficult in actual reconstruction of these displacements to evaluate the unmeasured displacements, especially if significant delays in instrument installation were permitted. Even under optimum installation conditions, the extensometers will have more unmeasured displacement and will be more difficult to reconstruct. The success of reconstructing complete displacement curves is perhaps the measure of the success of any

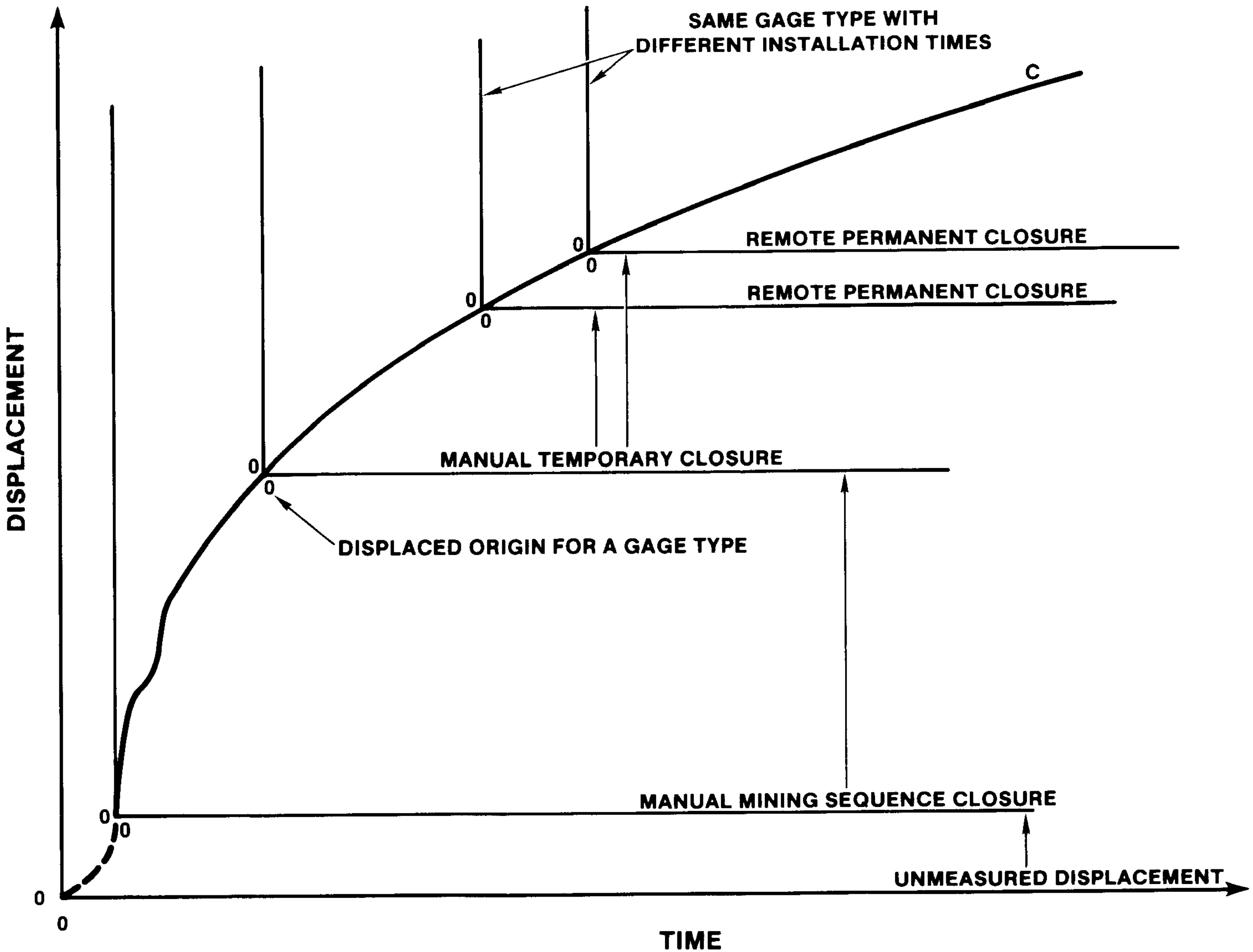

Figure 6.0.2. Reconstruction Schematic for Closure Measurements

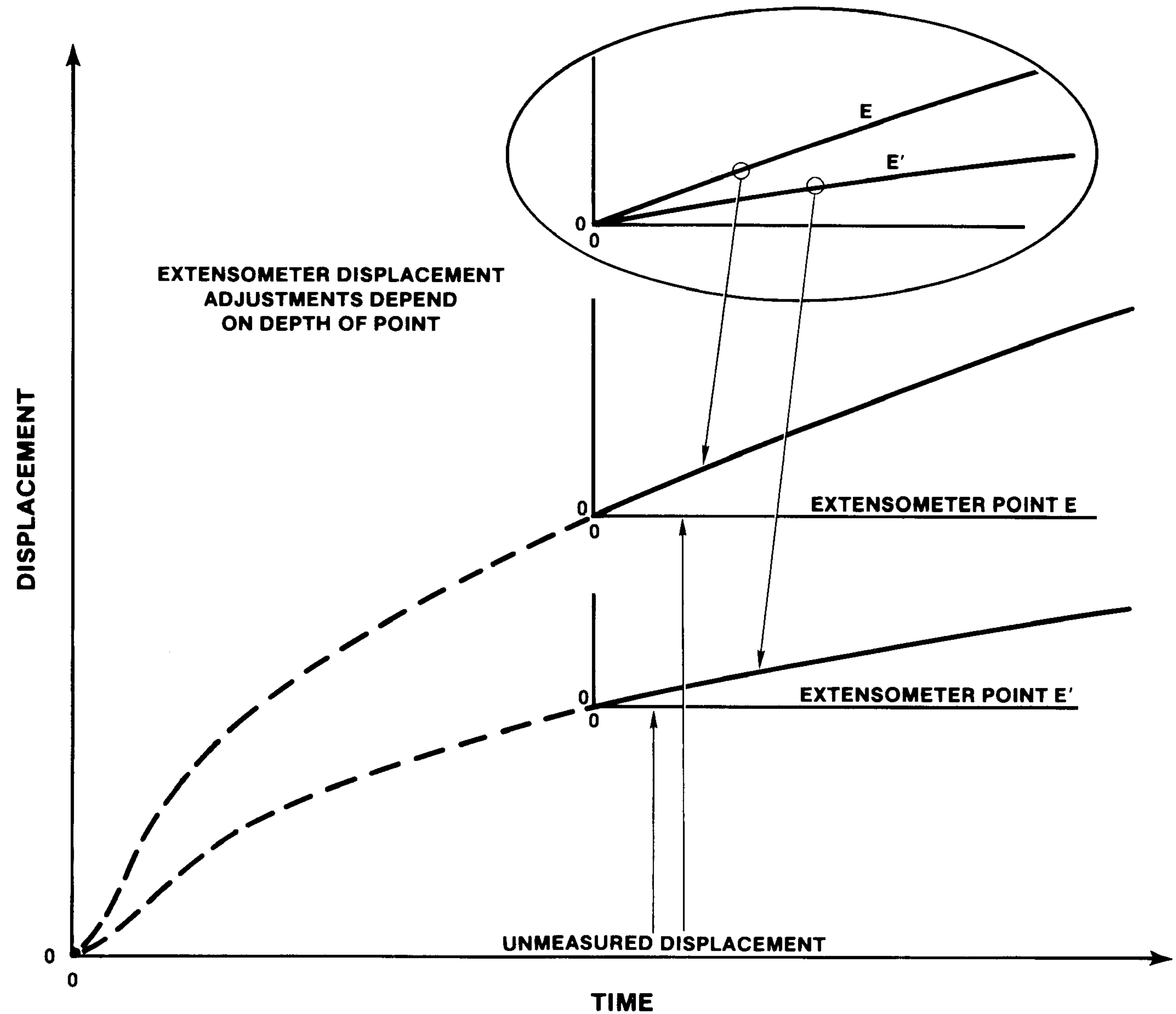

Figure 6.0.3. Reconstruction Schematic for Extensometer Measurements

analysis of in situ data. As a corollary, numerical simulations that ignore the realities of collecting field data may also be less than successful.

Interpretation of stress meter data obtained in salt, a creeping material, is especially difficult both conceptually and in practice. Any underground opening, regardless of size, introduces a change in the existing stress field. Thus, excavation of a room such as Room H changes the virgin, lithostatic pressure field to a stress field, which now acquires both spherical (hydrostatic) and deviatoric (shear) components. The magnitudes of these components at a given location around the room will change with time because the deviatoric (shear) component drives the material creep deformation. The problem is compounded by the need to emplace stress meters in this already complex stress field to interrogate the stress. When a hole is drilled into the stress field around the room, the hole is itself an opening that perturbs the room's stress field. The borehole-induced stress changes are time-dependent, just as in the case of the changes induced by the room.

Introducing a gage into the system further complicates the picture. All stress meters interact with the borehole wall to produce either displacement or pressure in the stress meter. This displacement or pressure, through calibration, often is taken as a measure of the stress in the salt. Although the gage may correctly give the gage/salt interface conditions, the interaction of the gage with the salt has itself, in all cases, perturbed the local stress field around the bore hole. This very complicated situation is shown, in part, in Figure 6.0.4. The figure represents the condition at a fixed time for a point R in the stress field

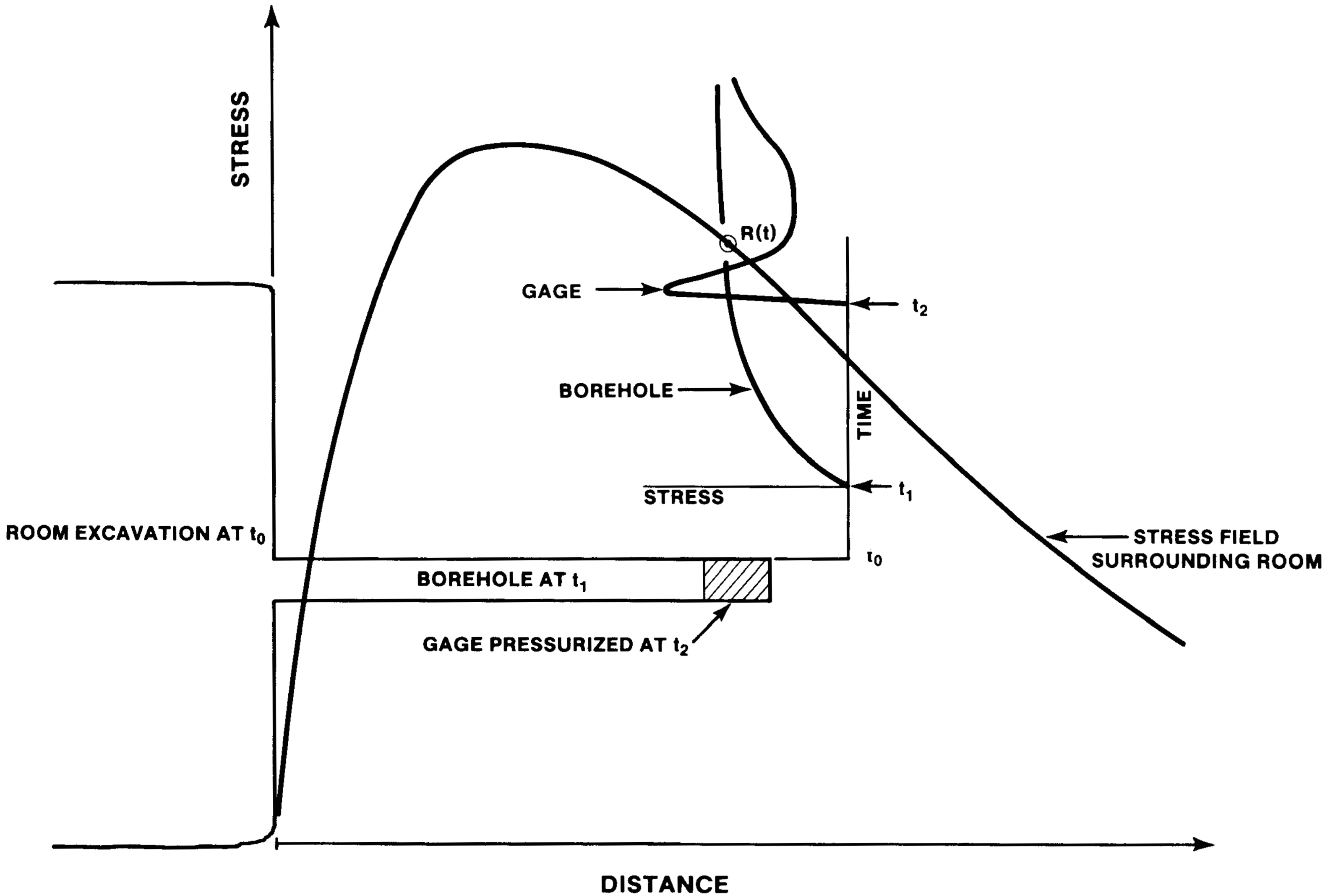

Figure 6.0.4. Schematic of Stress Field Perturbations

around the room. The stress field around the room originated at the time of mining of the room and has evolved continuously since then. This point is then intercepted by the perturbation stress field from the gage borehole when it is drilled at a later time, which causes a modification of the stress at R. Insertion of the gage (and in this case pressurization or prestressing to some predetermined installation value) at a still later time modifies the local stress field around the gage. As indicated, the times differ at which all these stress perturbations of the virgin stress field occur because they are controlled by access and installation delays in fielding the gage. Clearly, simplistic interpretations of the stress meter results are not possible under such complex interactions. Sophisticated numerical analysis of the room/borehole/gage configuration, with correct time sequencing, will be necessary. The least complex situation for the stress meter results is found when, if ever, the stresses from all perturbations come into equilibrium.

Fortunately, temperature measurements require little, if any, interpretive aids. The times and magnitudes of heat application are well defined. If the in situ fielding process has eliminated or minimized unknown heat losses and sources, the measured temperatures can be readily analyzed with numerical techniques.

7 SUMMARY

A wealth of technical information and data for the Heated Axisymmetric Pillar Test (Room H) is presented in this report. These data include extensive structural and thermal measurements taken during the time span from the beginning of the room development (February 1985) to the present (April 1987). Extensive structural data include closure displacement, extensometer displacement, and stress; and very complete thermal data include temperature, heater flux, and heater power.

The intent of this report is to make the results of this large-scale, in situ test available to analysts and other interested persons. The presentation of the data is organized to permit easy access to data of a given type of gage or specific gage. However, keys are given to the data presentation so that special collections of data can be made according to the needs of the analyst.

Because of the complex nature of the time-dependent response of underground openings salt, interpretation aids are required to put the data into proper context. For proper analysis, it is essential the interpretation framework be understood.

The data of the Heated Axisymmetric Pillar Test (Room H) will be updated, as necessary, in future reports.

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