

TRANSLATION

TITLE

: - as translated into . E . N . G . L . I . S . H

GKM II-M CONDENSATION TESTS

DESCRIPTION OF THE MEASUREMENT CONCEPT

- as translated from . G . E . R . M . A . N

GKM II-M CONDENSATION TESTS

BESCHREIBUNG DES MESSKONZEPTES

POOR ORIGINAL

AUTHOR/S/ : SCHMID, KEMPF

SOURCE : KWU WORKING REPORT R 541/10/79

1237 263

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for

PP&L

PENNSYLVANIA POWER
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ALLENTOWN, PENNSYLVANIA

by

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Working Report

 - R 541/10/79
 Number Dept./No./Year

Title

GKM-II-M Condensation Tests

Description of the measurement concept

 Karlstein, 11 April 79
 Place, date

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| Schmid | R541 | 328 |
| Kempf | R522 | 543 |
| Author | Dept. | Tel. |

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PP&L, SSES Units 1 and 2, CCOP Tests

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Summary

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Under contract to the Pennsylvania Power & Light Company (PP&L), the KWU is preparing transient condensation tests of the pressure suppression system in the Grosskraftwerk Mannheim (GKM). These tests will be performed in the modified GKM II test stand (single cell with proportionate drywell and suppression chamber at actual scale). The purpose of the tests is to verify the design of the pressure suppression systems of the Susquehanna 1 and 2 nuclear power plants.

The test stand is extensively instrumented. Two instrumentation systems are installed: operating instrumentation and test instrumentation.

The purpose of the operating instrumentation is to control the test sequence and ensure safe monitoring of the test stand. A process control computer is used for data acquisition.

The purpose of the test instrumentation is to collect all relevant data needed to evaluate the various phenomena. The measurement signals from the individual transducers are recorded on magnetic tape, light-spot line recorders and to some extent by the process control computer.

A survey of the instrumentation and its arrangement is given in Figures and Tables.

 /s/ Schmid /s/ Kempf
 Authors' signatures
 Schmid Kempf

 /s/ Becker /s/ Sack
 For ext. releas.
 Dr. Becker, R141 Sack, RF132 16 May 7

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1. Introduction

KWU is preparing in the GKM a test program for the performance of transient condensation tests on the pressure suppression systems of the Susquehanna 1 and 2 BWR plants.

A detailed description of the instrumentation, test set-up and test execution will be included in the Test Procedure which is being prepared for those tests.

The tests are performed in a rebuilt condensate accumulator. It conservatively simulates the smallest single cell of the pressure suppression system of the Susquehanna 1 and 2 plants. The volume of the proportionate upper annulus (drywell) is simulated by a mounted accumulator.

A replaceable standard orifice installed in the blowdown line simulates the postulated break cross-section of a main-steam line or feedwater line. The "break cross-section" is released by means of a rupture disk combination.

This report gives a first survey of the instrumentation of the test stand, which is subdivided into operating and test instrumentation.

The purpose of the operating instrumentation is to control the test sequence and monitor the test stand. The test instrumentation ensures the recording of all data of significance for evaluation of the phenomena which occur during air-poor condensation.

2. Identification system for the instrumentation

The measurement transducers are identified by a system of letters and numbers. Each identification starts with a letter or letters describing the type of transducer:

P for Pressure Transducer
T for Temperature Sensor (Thermocouple)
L for Water Level Measurement
DG for Displacement Gage
SG for Strain Gage
I for Electrical Impulse Signal
LP for Level Probe
LC for Load Cell
AF for Air Fraction
OR for Oxygen Rate

Following these letters is a number which characterizes the mounting location or measurement location in the test stand. For that purpose, the test stand is divided imaginarily into different System Groups as follows (see Fig. 1):

- System Group 1 contains transducers on the steam lines to the accumulator S6 and to the feedwater tank B 202 and in the feedwater tank B 203
- System Group 2 contains the feedwater tank B 202
- System Group 3 characterizes the steam accumulator S6
- System Group 4 contains the steam supply to the test stand
- System Group 5 contains the instrumentation of the proportionate drywell with the vent pipe
- System Group 6 characterizes the suppression chamber

The System Groups 1-4 contain the operating instrumentation, while groups 5 and 6 characterize the test instrumentation.

After this identification number there is a decimal point which separates this number from the running numbers of the transducers.

3. Operating instrumentation

The purpose of the operating instrumentation (see Tables 1 and 2, Figures 1, 3 and 4) is to monitor the steam accumulator, feedwater tank and steam lines. The signals from the measurement transducers are interrogated by a process control computer and recorded. This computer is a part of the operating instrumentation. All data are stored on magnetic tape and can be printed out or plotted after each test. Before test start, the process control computer compares the recorded measurement signals with prescribed setpoint values and prints them out. If the measurement value differs from the setpoint value by a prescribed percentage, that measured value is identified in the printout.

The operating instrumentation concentrates on the measurement of pressures, temperatures and water levels in the steam accumulator, steam lines and feedwater tanks.

4. Test instrumentation

The test instrumentation (see Tables 3-7 and Figures 3-6) records all the data needed to evaluate the phenomena occurring during air-poor steam condensation and the resulting loads in the pool, and also the data needed to determine the steam flow rate in the piping. The dynamic pressure loads are measured at several points in the pool. The forces occurring at the vent pipe bracing and at internals in the suppression chamber and at its structure are recorded by strain gages or load cells. The pressure build-up in the vent pipe is measured at several points. In addition, Level Probes are installed at the vent pipe so as to be able to record the dynamic behavior of the water surface. Pressure and temperature measuring points in the air space of the suppression chamber and in the proportionate accumulator provide information about the variation of pressure and temperature during the tests. Two differential-pressure measuring points in the water region of the suppression chamber record the air bubble fraction in the pool. At the upper end of the vent pipe there are two measuring points for determination of the air content of the steam, one measuring point for continuous sampling, and one other measuring point for discontinuous sampling. The measurement system for continuous sampling is provided by SRI. SRI * is also providing assistance in the design of the second system.

The data is recorded on magnetic tape in analog form by means of carrier-frequency amplifiers and dc amplifiers. This ensures that high-frequency measurement signals are recorded with proper frequency and amplitude. The data is reduced later by a computer. Simultaneously with the recording on magnetic tape, most of the measurement points are also recorded on light-spot line recorders. That type of recording makes it possible to get a quick look at important measurement variables shortly after each test. At the same time, a few selected transducer channels of the test instrumentation are recorded additionally at the process control computer. This procedure makes it possible to perform a quick and simple summary evaluation of that data after each test.

All the measurement channels run together at a measurement place which is located in an air-conditioned measurement container.

Each measurement chain consists of a transducer, connection cable, amplifier (carrier-frequency or dc amplifier), balancing unit and recording unit (see Fig. 7).

* Stanford Research Institute International

The utilized pressure transducers have a measuring diaphragm and a foil strain gage system which is directly connected to the diaphragm. All pressure transducers in the water region of the suppression chamber have an exposed measuring diaphragm with direct contact to the surrounding water. Earlier studies by KWU have shown that this type of transducer is best suited for recording higher-frequency pressure oscillations with correct frequency and amplitude.

For the pressure measurement in the lines which carry steam, the measuring diaphragm has to be protected from the hot steam. That is accomplished by means of a short water-filled pipe which connects the transducer to the measurement site.

The transducers are connected to the measuring amplifiers by shielded cables. Carrier-frequency amplifiers providing a frequency resolution of up to 1 kHz are used for the strain gages, displacement transducers and pressure transducers. DC amplifiers with a 10 Hz low-pass filter are used for the temperature measurement.

5. Filming of the processes in the pool

The processes in the water region of the suppression chamber are recorded optically on film by a high-speed camera and on video tape by a television camera.

The cameras are mounted outside the tank and observe the processes by means of bull's eyes. Several underwater searchlights are installed in order to ensure satisfactory lighting of the end of the vent pipe.

A uniform electrical reference signal ensures time correlation between all the data acquisition systems.

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6. Note

The following additional abbreviations are used in Tables 1-7.

| | |
|-------|--|
| DPS | <u>D</u> ata <u>P</u> rocessing <u>S</u> ystem |
| CTC | <u>C</u> oated <u>T</u> hermocouple |
| DCA | <u>D</u> irect <u>C</u> urrent <u>A</u> mplifier |
| CFA | <u>C</u> arrier <u>F</u> requency <u>A</u> mplifier |
| HT-SG | <u>H</u> igh <u>T</u> emperature <u>S</u> train <u>G</u> age |
| PG | <u>P</u> ressure <u>G</u> age |
| RTD | <u>R</u> esistor <u>T</u> emperature <u>D</u> etector |

Tr. note: The column headed "Transducer Dates" should read "Transducer Data". This is an incorrect translation by KWU of the German word "Daten", which can mean either "dates" or "data" in English!

| KWU R541 | | GKM II - M - Condensation Tests -Operating Instrumentation - | | | | | | | | Date 4/11/79 | |
|-------------|--|---|-----------------------|-----------------|-----------|---------------------|-----------------|-----------------|---------------|-----------------|--|
| Transducer | Measuring - Point Marking | Measuring - Location | Transducer Dates | | | Measuring Amplifier | Recording Place | | | Figure | |
| | | | Type | Measuring Range | Stock-No. | | DPS Channel | Control Station | Test Facility | | |
| P 1.1 | Pressure in the superheated steam line | steam line to the steam accumulator | PG with remote sensor | 25 bar | | 20 mA | X | X | | 1 | |
| P 1.2 | " | main steam line | " | " | | " | X | X | | 1 | |
| P 1.3 | Pressure in the feedwater tank | feedwater tank B 203 | " | " | | " | | X | | 1 | |
| P 2.1 | " | feedwater tank B 202 | " | 50 bar | | C F A | X | X | | 1 | |
| P 3.1 | Pressure in the steam accumulator, steam zone | | " | " | | " | X | X | | 1 | |
| L 3.1 | Water level in the steam accumulator | | Barton cell | 2 bar | | 20 mA | X | X | | 1 | |
| L 3.2 | " | | " | 0.2 bar | | 20 mA | X | X | | 1 | |
| L 3.3 | " | | Water gage | - | | - | | | X | 1 | |
| P 4.1 | Pressure in the blowdown line before throttle nozzle | | SG complete bridge | 50 bar | | C F A | | X | | 1 | |
| P 4.4 | Pressure in the blowdown line before the rupture discs | | PG with remote sensor | 25 bar | | 20 mA | X | X | | 1 | |
| P 4.5 | Pressure between the two rupture discs | | " | " | | " | X | X | | 1 | |
| T 1.1 | Temperature in the superheated steam line | steam line to the steam accumulator | C T C | 550°C | | D C A | X | X | | 1 | |
| T 1.2 | " | main steam line | C T C | 400°C | | " | X | X | | 1 | |

| KWU R541 | GKM II - M - Condensation Tests -Operating Instrumentation - | | | | | | | | | Date 4/11/79 |
|-------------|--|---------------------------|----------------------|--------------------|------------------|------------------------|-----------------|---|--|-----------------|
| | Transducer | Measuring - Point Marking | Measuring - Location | Transducer Dates | | Measuring Amplifier | Recording Place | | | Figure |
| Type | Measuring Range | Stock-No. | DPS Channel | Control Station | Test Facility | | | | | |
| T 1.3 | Temperature in the feedwater tank | feedwater tank B 203 | C T C | 300 ^o C | | D C A | | X | | 1 |
| T 2.1 | " | feedwater tank B 202 | " | " | | " | X | X | | 1 |
| T 3.1 | Temperature in the steam accumulator, steam zone | | " | " | | " | X | X | | 1 |
| T 3.2 | Temperature in the steam accumulator, water zone | | " | " | | " | X | X | | 1 |
| T 3.3 | Temperature for the correction of the water level measurement in the steam accumulator | | " " | " | | " | X | X | | 1 |
| T 4.1 | Temperature in the blowdown line before the throttle nozzle | | " | " | | " | X | X | | 1 |
| | | | | | | | | | | |
| T 5.4 | Temperature in the drywell, at the wall | | " | " | | " | X | X | | 1,3,4 |
| L 6.1 | Water level in the suppression pool | | Barton cell | 2 bar | | 0...20mA | X | X | | 3,4 |
| L 6.2 | Water level in the annulus gap | | " | " | | " | X | X | | 3,4 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

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Tab 2

| KWU R 541 | | GKM II-M-Condensation Tests - Test Instrumentation - | | | | | | | | | Date 4/11/79 |
|--------------|---|---|-----------------------|-----------------------------|----------------------|--------------------|------------------------|----------------|-----------------|------------------|-----------------|
| Transducer | Measuring-Point Marking | Measuring Location | | Transducer | | Dates Stock-No. | Measuring Amplifier | Data Recording | | | Figure |
| | | Level H (mm) | Angle \angle (°) | Type | Measuring Range | | | DPS Channel | Visi- corder | Magnetic Tape | |
| SG 6.3 | Strain in the tank wall, outside, vertical | 2650 | 90 | SG semi bridge | 6000 $\mu\text{m/m}$ | | C F A | | X | X | 5 |
| SG 6.4 | Strain in the tank wall, outside, horizontal | 2650 | 90 | " | " | | " | | X | X | 5 |
| SG 6.5 | Strain in the tank wall, outside, vertical | 2650 | 0 | " | " | | " | | X | X | 5 |
| SG 6.6 | Strain in the tank wall, outside, horizontal | 2650 | 0 | " | " | | " | | X | X | 5 |
| SG 6.7 | Vertical bending strain at the quencher dummy | 1100 | 270 | " | " | | " | X | X | X | 5 |
| SG 6.8 | Horizontal bending strain at the quencher dummy | 1100 | 270 | " | " | | " | X | X | X | 5 |
| SG 6.9 | Vertical bending strain at the legs of the test vessel | - | 0 | " | " | | " | | X | X | 4 |
| SG 6.10 | Vertical bending strain at the legs of the test vessel | - | 90 | " | " | | " | | X | X | 4 |
| DG 6.1 | Displacement of the bottom of the inner cylinder | 0 | center | inductive semi bridge | 2 mm | | " | | X | X | 5 |
| DG 6.2 | Displacement of the inner cylinder at the crossing place | 10000 | 270 | " | " | | " | | X | X | 5 |
| DG 6.4 | | | 90 | | | | | | X | X | |
| DG 6.3 | Displacement of the inner cylinder at the crossing place | 10000 | 0 | " | " | | " | | X | X | 5 |
| DG 6.5 | | | 180 | | | | | | X | X | |
| DG 6.4 | Displacement at the stiffening ring | 6090 | 90 | " | " | | " | | X | X | 5 |
| T 6.1 | Temperature in the suppression pool, water zone | 6800 | 180 | C T C | 300°C | | D C A | X | X | X | 5 |
| T 6.2 | 1237" 272 | 5200 | 180 | " | " | | " | X | X | X | 5 |

| KWU R541 | | GKM II-M-Condensation Tests - Test Instrumentation - | | | | | | | | | Date 4/11/79 |
|-------------|---|---|---------------------|---------------------------|--------------------|-----------|---------------------|----------------|-----------------|------------------|-----------------|
| Transducer | Measuring-Point Marking | Measuring Location | | Transducer Data | | | Measuring Amplifier | Data Recording | | | Figure |
| | | Level H (mm) | Angle ϕ (°) | Type | Measuring Range | Stock-No. | | DPS Channel | Visi- corder | Magnetic Tape | |
| T 6.3 | Temperature in the suppression pool, water zone | 3650 | 180 | C T C | 300°C | | D C A | X | X | X | 5 |
| T 6.4 | " | 2650 | 180 | " | " | | " | X | | | 5 |
| T 6.7 | " | 1100 | 180 | " | " | | " | X | | | 5 |
| T 6.8 | " | 0 | center | " | " | | " | X | | | 5 |
| T 6.9 | Temperature in the suppression pool, air zone, top | 14100 | 270 | " | " | | " | X | | | 4 |
| T 6.10 | Temperature in the suppression pool, air zone, below | 8010 | 270 | " | " | | " | X | | | 1, 5 |
| P 4.1 | Pressure in the blowdown line before throttle nozzle | - | - | SG complete bridge | 50 bar | | C F A | X | X | X | 1 |
| ΔP 4.2 | Differential pressure at the throttle nozzle | - | - | " | 35 bar | | " | X | X | X | 1 |
| ΔP 4.3 | " | - | - | Barton cell | 4 bar | | 20 mA | X | X | X | 1 |
| T 4.1 | Temperature in the blowdown line before throttle nozzle | - | - | C T C | 300°C | | D C A | X | | | 1 |
| P 3.2 | Dynamic pressure in the steam accumulator, water zone | - | - | Piezo-electric transducer | 20 bar | | Charge amplifier | | X | X | 1 |
| P 5.1 | Pressure in the drywell | - | - | SG complete bridge | 20 bar | | C F A | X | X | X | 4 |
| P 5.2 | Pressure in the downcomer pipe, top | 15550 | 270 | " | 10 bar | | " | | X | X | 4 |
| P 5.3 | Pressure in the downcomer pipe, middle | 10580 | 270 | " | " | | " | | X | X | 4 |

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| KWU R541 | | GKM II-M-Condensation Tests - Test Instrumentation - | | | | | | | | | Date 4/11/79 |
|----------------|---|---|-----------------------|--------------------------|--------------------|--------------------|------------------------|----------------|-----------------|------------------|-----------------|
| Transducer | Measuring-Point Marking | Measuring Location | | Transducer | | Dates Stock-No. | Measuring Amplifier | Data Recording | | | Figure |
| | | Level H (mm) | Angle \angle (°) | Type | Measuring Range | | | DPS Channel | Visi- corder | Magnetic Tape | |
| P 5.4 | Pressure in the downcomer pipe,below | 7300 | 270 | SG complete bridge | 10 bar | | C F A | | X | X | 4 |
| P 5.5 | Pressure in the downcomer pipe,exit | 3750 | 270 | " | " | | " | | X | X | 4 |
| Δ P 5.6 | Pressure differential between dry- well and suppression chamber | - | - | " | 3,5 bar | | " | X | X | X | 4 |
| OR 5.1 | Oxigene rate in the downcomer pipe | 15550 | 270 | | - | | | X | | X | 4 |
| OR 5.2 | " | 15550 | 270 | | - | | | X | | X | 4 |
| DG 5.1 | Indication of the swing check valve between drywell and suppression chamber | - | - | | - | | C F A | X | | | |
| DG 5.2 | " | - | - | | - | | " | X | | | |
| T 5.1 | Temperature in the drywell,top | - | - | C T C | 300°C | | D C A | X | | | 4 |
| T 5.2 | Temperature in the drywell,below | - | - | " | " | | " | X | | | 4 |
| T 5.3 | Temperature in the drywell,ump | - | - | " | " | | " | X | | | 4 |
| T 5.5 | Temperature in the downcomer pipe,middle | 10580 | 270 | " | " | | " | X | | | 4 |
| T 5.6 | Temperature in the downcomer,exit | 3750 | 270 | " | " | | " | X | X | X | 4 |
| P 6.1 | Pressure at the suppression pool wall,water zone | 6150 | 180 | SG complete bridge | 10 bar | | C F A | X | X | X | 5 |
| P 6.2 | " | 4150 | 180 | " | " | | " | X | X | X | 5 |

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| KWU R541 | | GKM II-M-Condensation Tests - Test Instrumentation - | | | | | | | | | Date 4/11/79 |
|-------------|--|---|-----------------------|--------------------------|--------------------|--------------------|------------------------|----------------|-----------------|------------------|-----------------|
| Transducer | Measuring-Point Marking | Measuring Location | | Transducer | | Dates Stock-No. | Measuring Amplifier | Data Recording | | | Figure |
| | | Level H (mm) | Angle \angle (°) | Type | Measuring Range | | | DPS Channel | Visi- corder | Magnetic Tape | |
| P 6.3 | Pressure at the suppression pool wall, water zone | 3650 | 180 | SG complete bridge | 10 bar | | C F A | X | X | X | 5 |
| P 6.4 | " | 2650 | 180 | " | " | | " | X | X | X | 5 |
| P 6.5 | " | 2650 | 0 | " | " | | " | X | X | X | 5 |
| P 6.6 | " | 2650 | 90 | " | " | | " | X | X | X | 5 |
| P 6.7 | " | 1100 | 180 | " | " | | " | X | X | X | 5 |
| P 6.8 | " | 0 | center | " | " | | " | X | X | X | 5 |
| P 6.9 | Pressure in the suppression chamber, air zone | 14100 | 270 | " | 20 bar | | " | X | X | X | 4 |
| AF 6.1 | Air fraction in the suppression chamber, water zone | 4150/6150 | 180 | " | 3,5 bar | | " | | X | | 5 |
| AF 6.2 | " | 2650/6150 | 180 | " | " | | " | | X | | 5 |
| LP 5.1 | Water level in the downcomer pipe | 3750 | 90 | spark plug | - | | D C A | | X | X | 5 |
| LP 5.2 | " | 4050 | 90 | " | - | | " | | X | X | 5 |
| LP 5.3 | " | 4450 | 90 | " | - | | " | | X | X | 5 |
| LP 5.4 | " | 6150 | 90 | " | - | | " | | X | X | 5 |
| LP 5.5 | " | 7950 | 90 | " | - | | " | | X | X | 5 |

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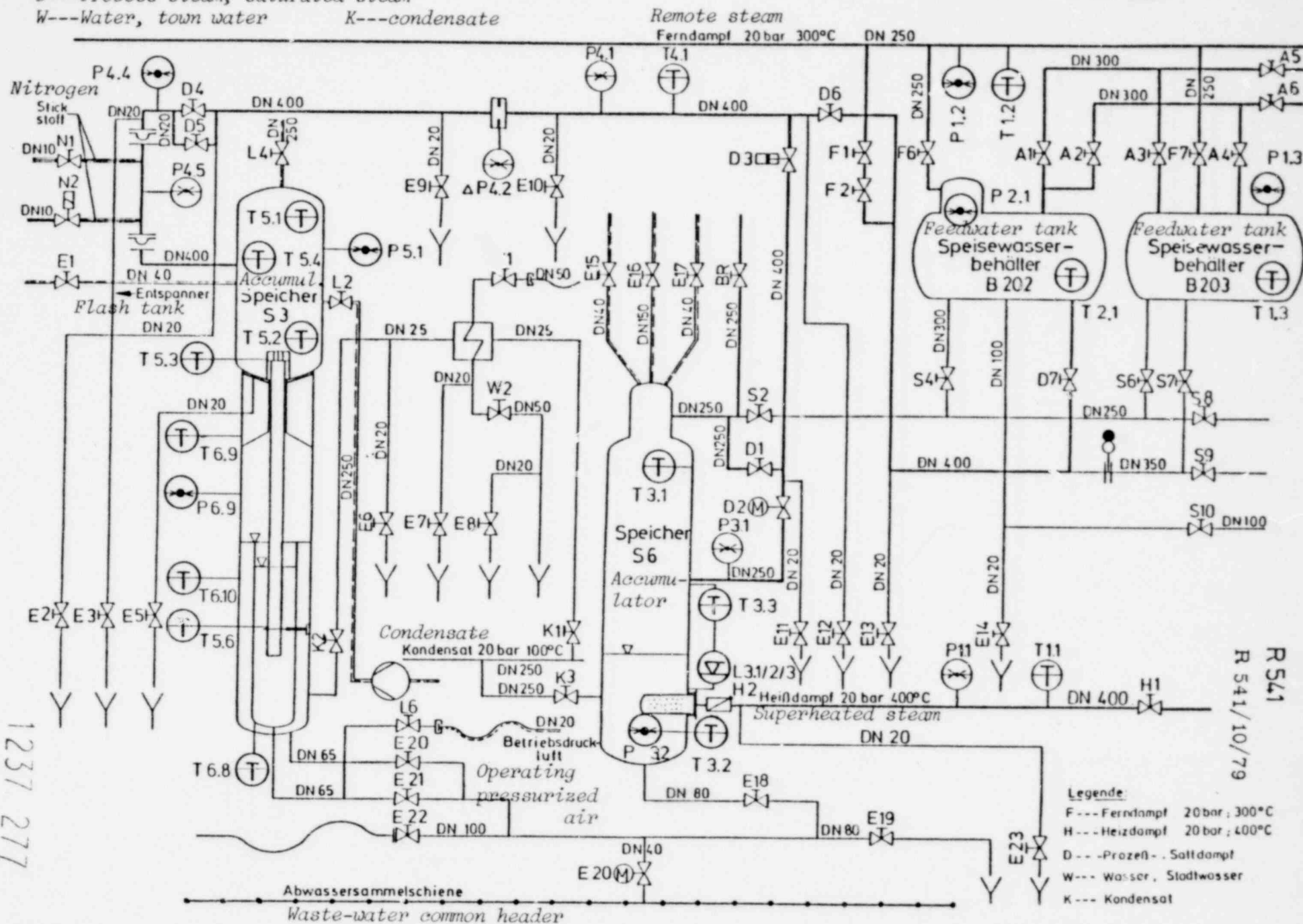
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Legend: F---Remote steam 20 bar, 300°C
H---Heating steam 20 bar, 400°C
D---Process steam, saturated steam
W---Water, town water K---condensate

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Test Stand Schematic Diagram

GKM II-M--Condensation Tests



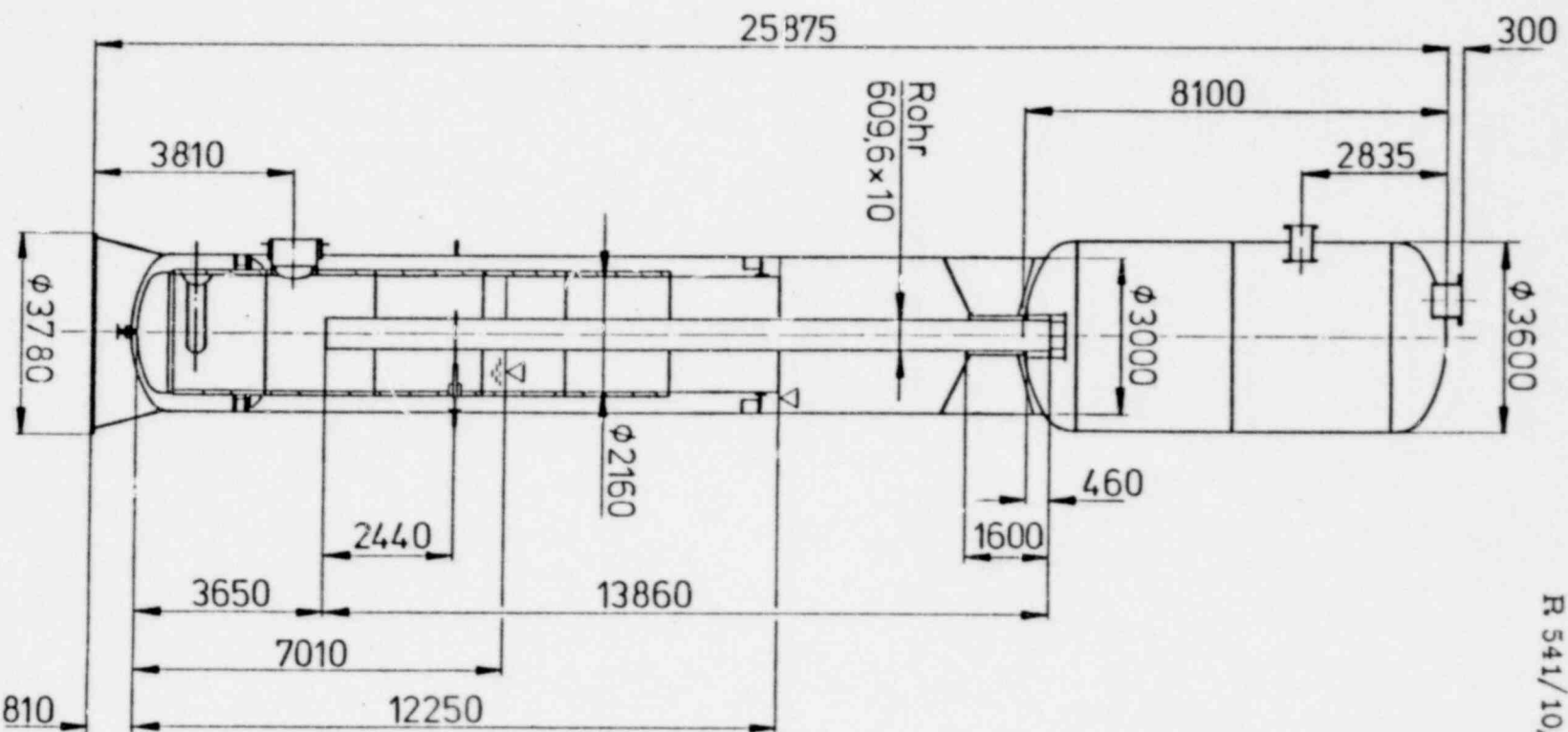
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Legende:
F --- Ferndampf 20 bar; 300°C
H --- Heizdampf 20 bar; 400°C
D --- Prozess- Sätteldampf
W --- Wasser, Stadtwasser
K --- Kondensat

Kraftwerk Union

Fig 1

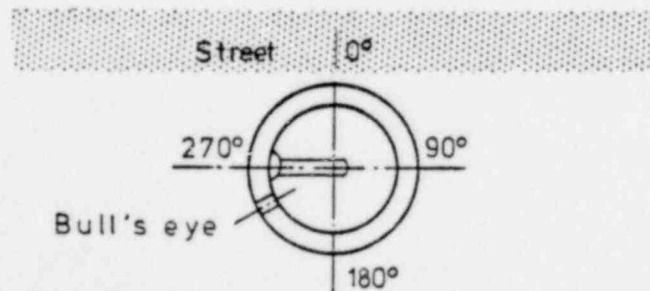
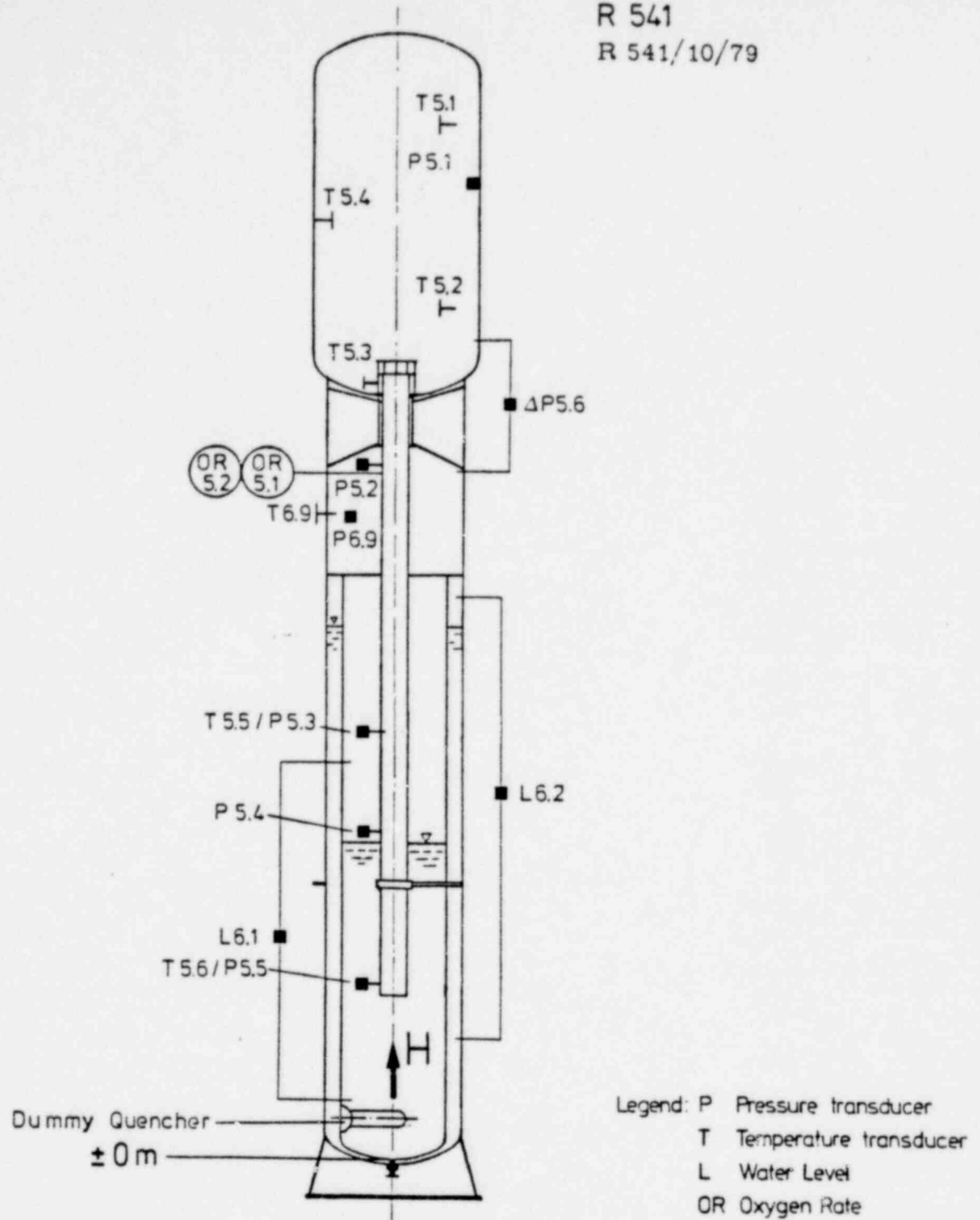
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GKM II-M-Condensation Tests
Test Tank

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Fig.2



GKM II - M - Condensation Tests

Coordinate System and Test Instrumentation

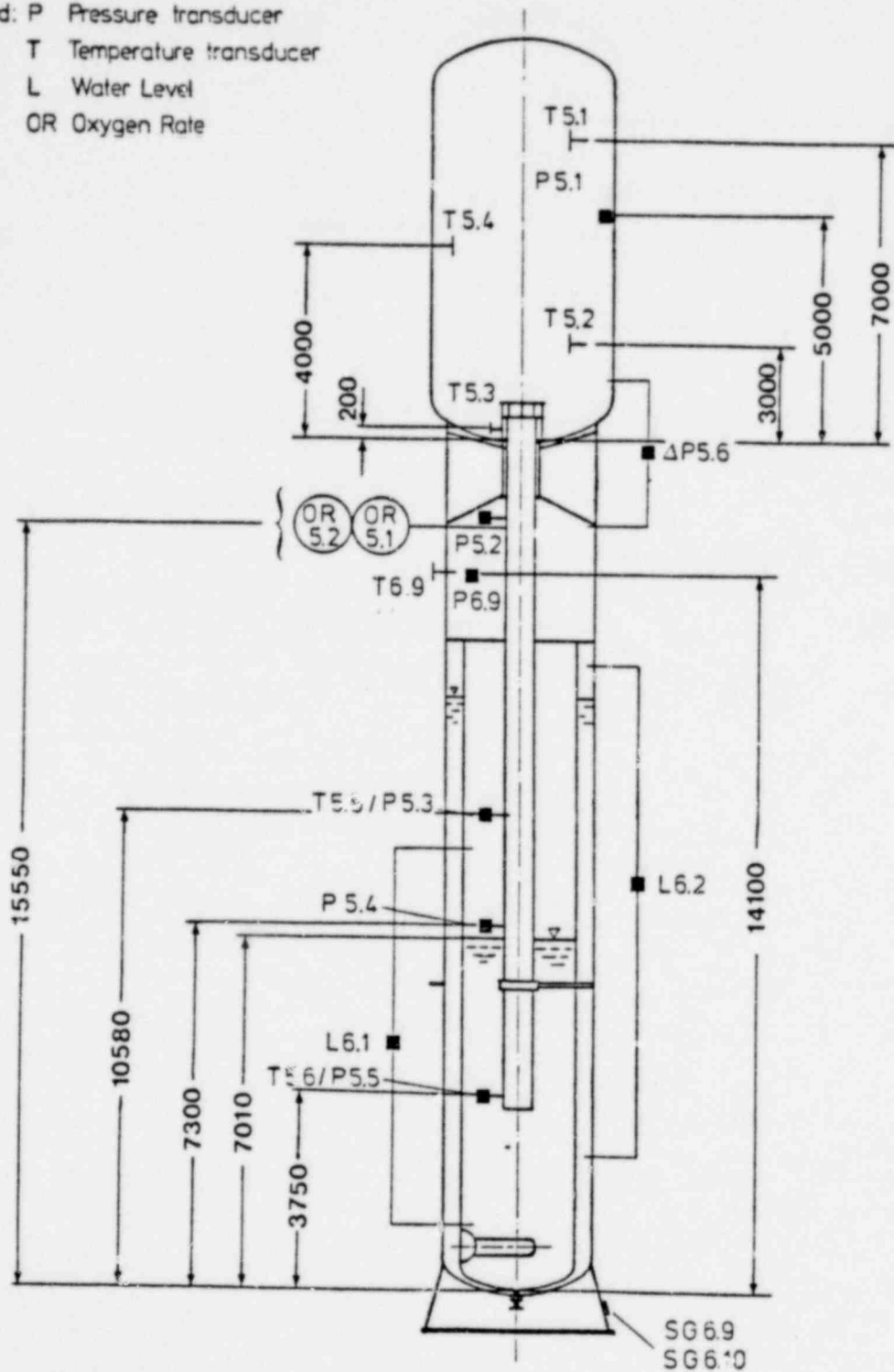
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Fig. 3

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Legend: P Pressure transducer
T Temperature transducer
L Water Level
OR Oxygen Rate



GKM II-M-Condensation Tests

Test Instrumentation

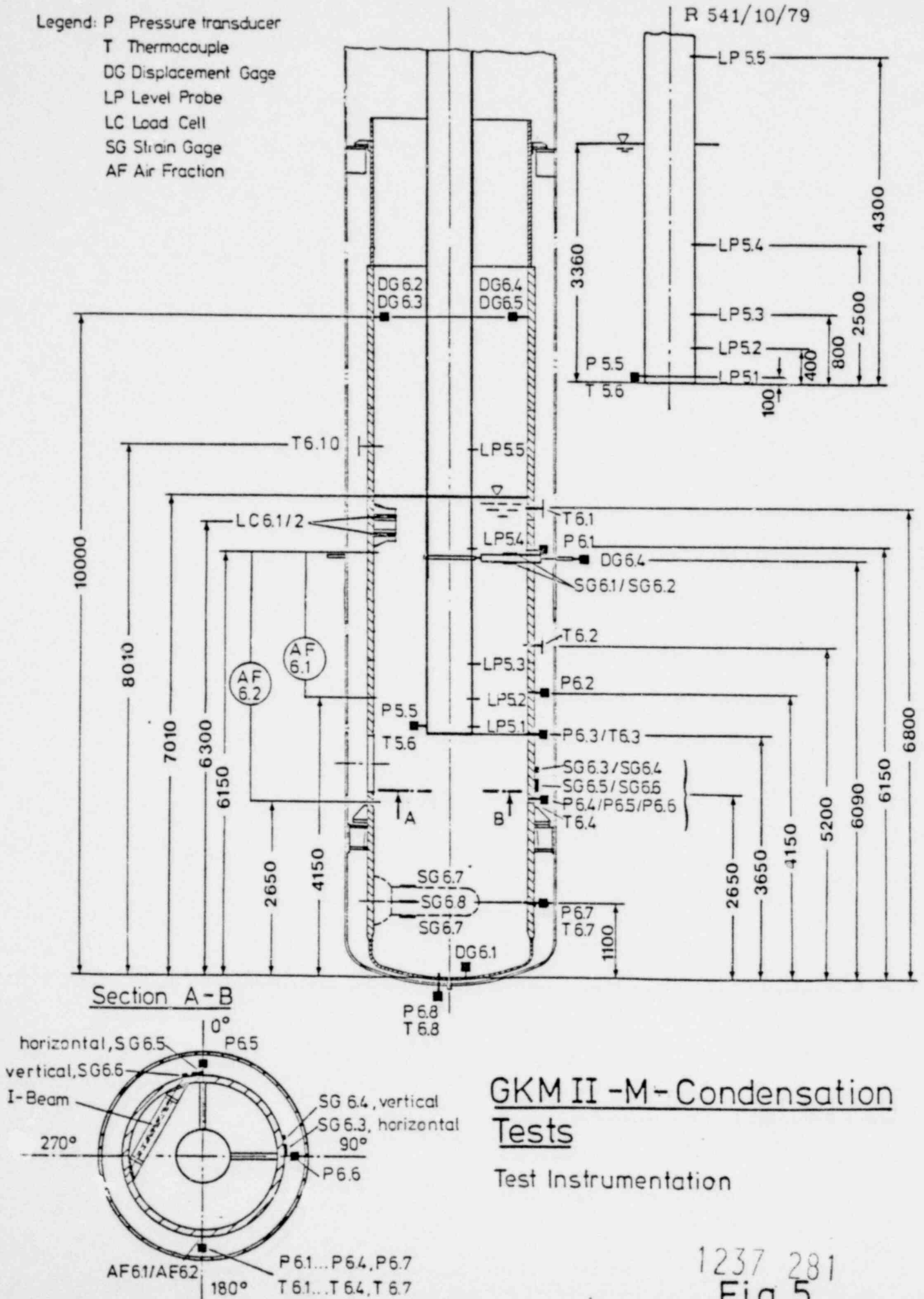
1237 280

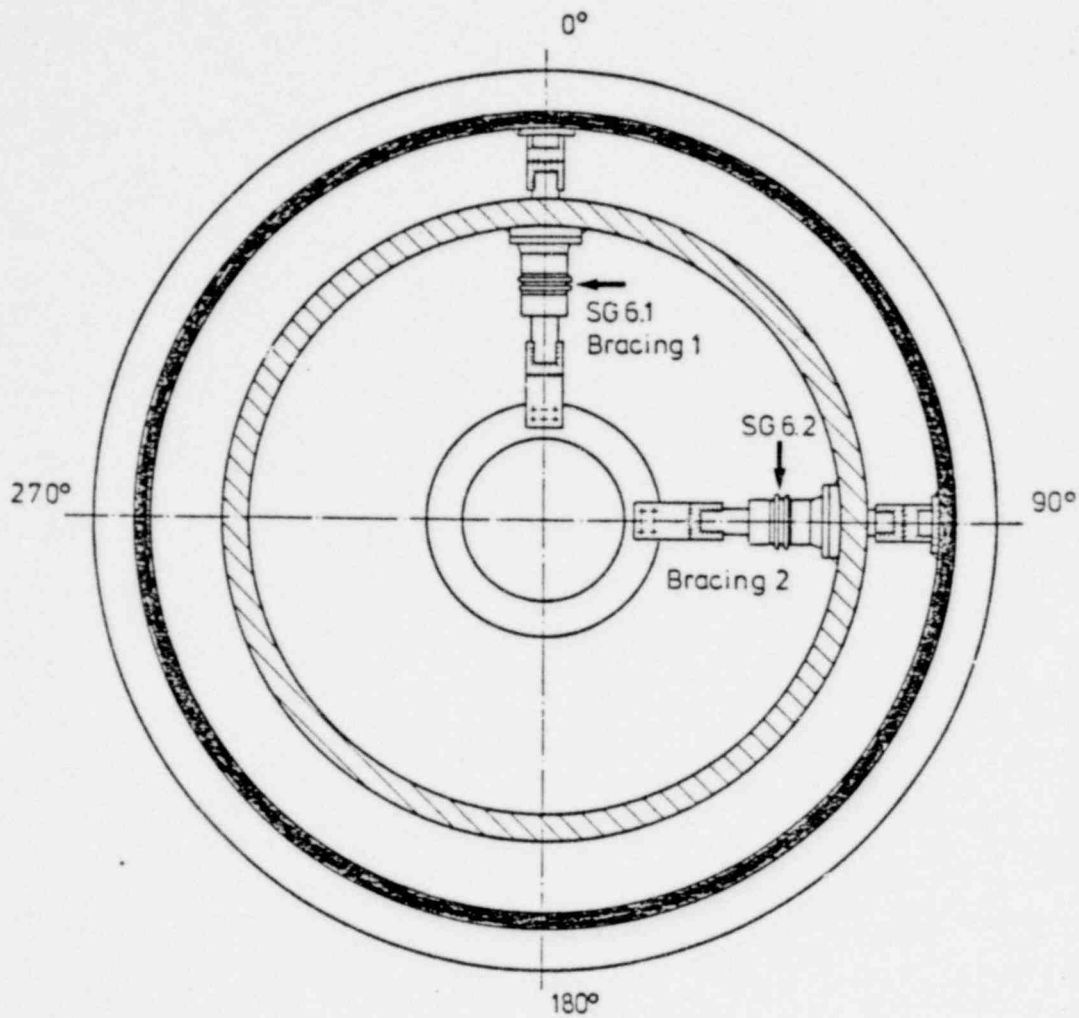
Fig. 4

R 541

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Legend: P Pressure transducer
T Thermocouple
DG Displacement Gage
LP Level Probe
LC Load Cell
SG Strain Gage
AF Air Fraction



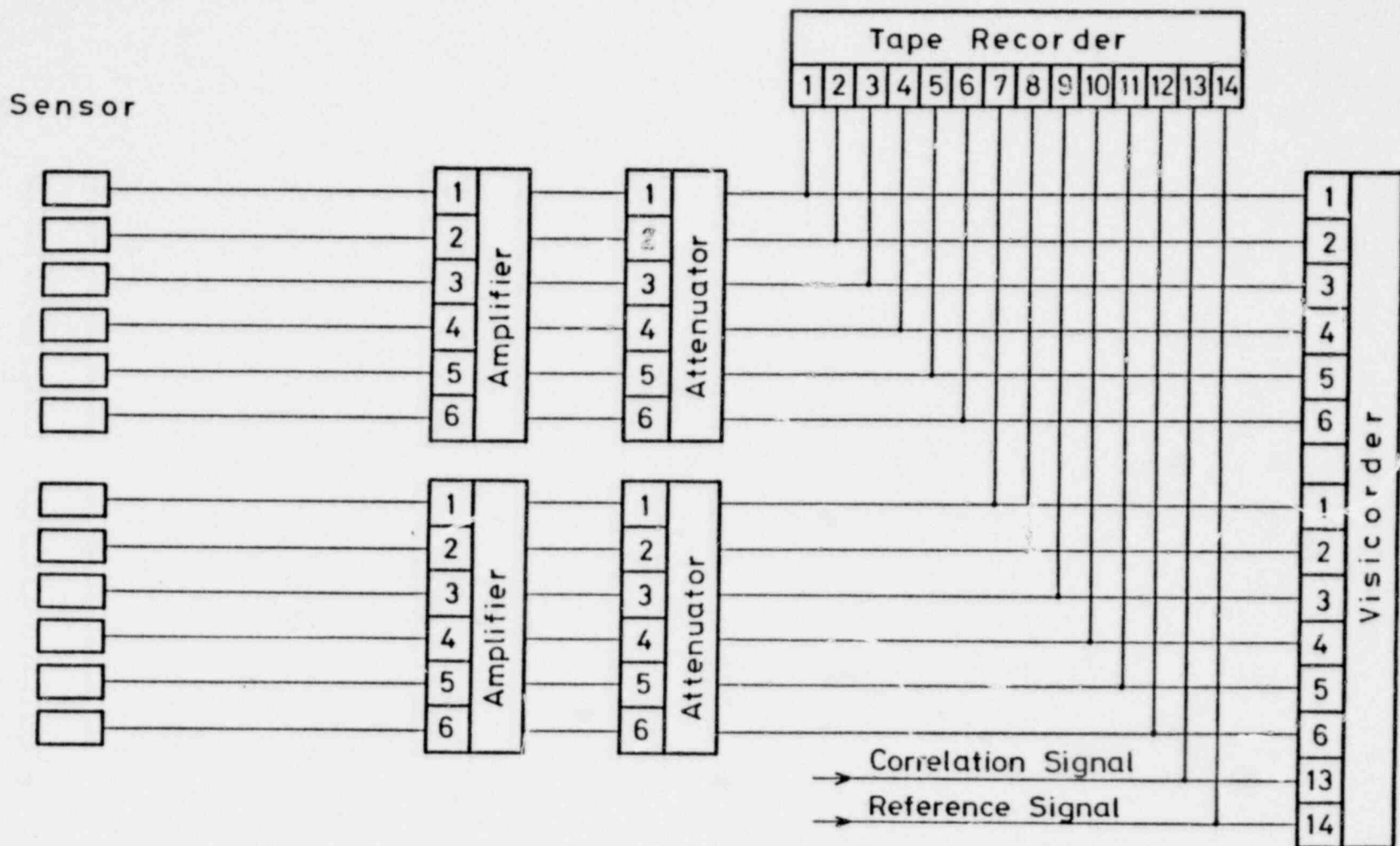


GKM II-M-Condensation Tests

Bracing Configuration

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Fig. 6



Data Recording: Schematic Block Diagram

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Fig. 7



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