# TRANSLATION

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

EXPECTED VALUES OF THE BLOWDOWN TESTS WITH THE RELIEF SYSTEM IN THE NON-NUCLEAR HOT TEST AT THE BRUNSBÜTTEL NUCLEAR POWER PLANT AND THEIR MEASUREMENT

– as translat...

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AUTHOR/S/

SOURCE

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71 BARNARD AVENUE, WATERTOWN MASSACHUSETTS 02172 (617) 924-5500

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i) ...." with a mass flow density of [redacted] Kg/$m^2$s...";

ii) 


iii) ...." should be kept below [redacted] atm."

iv) 

8/17/78

| | |
|---|---|
| Offenbach/Main | 30 September 1974 |
| Place | Date |

Technical Report KWU/R 1 - 3141

File number R 113-SD

Author Dr. Becker

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Relief system, perforated pipe quencher, suppression chamber, thermohydraulic loads

Summary

On the basis of model tests in the Grosskraftwerk Mannheim (GKM) [Mannheim Central Power Station] at a 1:5 scale and in the Grosswelzheim model test stand at a 1:100 scale, detailed statements are made concerning the expected measurement values in the non-nuclear hot tests in the Brunsbüttel nuclear power plant with the actual relief system. In particular, the statements relate to

- the behavior of the relief valve,
- the thermohydraulic loads on the relief system, the suppression chamber and its internal fittings, and
- the temperature mixing.

Parameter studies permit an immediate evaluation of the measurement values and make extrapolations possible. The measurement of the quantities of interest is described in detail and load-stress variations for the test evaluation are indicated.

/s/ (Dr. Becker)

/s/ (Göbel)

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TABLE OF CONTENTS

## 1. Introduction

The start-up tests in the Kernkraftwerk Würgassen (KWW) [Würgassen nuclear power plant ] show that large forces can be exerted on the containment by the pressure relief system. These involve air oscillations during vent clearing and the pulsations for condensation at high water temperatures. In a development program with model tests in the GKM at a 1:4 scale, it was possible in the summer of 1972 to achieve a reduction of the air oscillations with a lower-limited valve opening time and an additional pre-impingement of steam. Tests in the KWW confirm the expected bottom pressures /1,2/.

This was followed by another development phase whose aim was to reduce the air oscillations and to make the temperature limit for the condensation less critical, using passive measures. Literature studies and screening tests in the GKM and model tank in the winter of 1972/73 /3/ led in April 1973 to the choice of the perforated-pipe quencher.

The essential model parameters were investigated in tests with a model perforated-pipe quencher. Test results and their interpretations are contained in /4,5,6/.

The conclusion of the development program is to be the non-nuclear hot tests in the Kernkraftwerk Brunsbüttel (KKB) [Brunsbüttel nuclear power plant] with the actual geometry. A test program with extensive instrumentation was set up for those tests/7/.

The intended test sequence is contained in Table 1. The purpose of the present report is to indicate expected values for the thermohydraulic quantities and parameter studies regarding the influential factors. These values and diagrams make possible an immediate evaluation of the measured values and an extrapolation to other operating magnitudes.

The measurement of the magnitudes of interest is described. The measuring points of thermohydraulic importance are plotted in Figures 1.1 to 1.5. The strain measurement points essential for determination of the forces are indicated for quick evaluation of the load-stress variations.

The deformations of the structure due to the applied loads are not a subject of this report. Additional measurement points are available during the hot tests to study this complex problem.

## 2. Opening time and flow rate of the safety/relief valve

Opening time and steam flow rate of the valves are not only of importance for the stressing of the relief system and suppression chamber, but also have considerable relevance from the standpoint of safety. Accordingly, these values deserve special attention.

Measurements of the opening time are already available, especially for the KWW valves built according to the same principles but designed for lower flow rates /8,9/. In addition, there are measurements in the GKM test stand for low system-pressures. From these, an expected value of ca. [redacted] ms is derived for the KKB valve. In the load data of Sections 3 and 4, the opening time is varied from [redacted] ms in order to point out its influence and make interpolations possible when there are deviations from the expected value.

In order to be able to judge the overall opening behavior of the valves, the "not closed" and "open" contact signals at the pilot valve and the pressure variation in the control line are measured in addition to the lift vs. time variation at the main valve.

Figures 2.1 and 2.2 show the valve flow rate expected by the valve manufacturer as a function of reactor pressure. This flow rate can be measured through the flow limiter installed in the main-steam line at the outlet of the reactor vessel (see Figure 2.3). Figures 2.4, 2.5 and 2.6 show the calculated characteristic

curves of the flow limiter used to evaluate the measurements. For comparison, the expected flow-rate variations for blowdowns from one and two valves are plotted in these characteristic curves (Figure 2.5 and Figure 2.6).

## 3. Internal pressure in the blowdown pipe and quencher

After the valve opens, steam flows into the blowdown pipe filled with air to the water level and causes a pressure rise which leads to expulsion of the water slug. As this happens there is a transient pressure-maximum (the so-called vent clearing pressure) which subsequently changes into the steady-state pressure.

### 3.1 Expected vent clearing pressures

For the relief system with perforated-pipe quencher, a theoretical vent clearing model was developed which represents an extension of the corresponding model for the plain-ended pipe and was adapted to the GKM tests /5/. The expected values of the vent clearing pressure calculated with this model are shown in Figure 3.1 as a function of the reactor pressure and valve opening time. The loss factor in the nozzle was fixed at [redacted] as an upper estimate. However, Figure 3.2 makes clear how slight the influence of this factor is on the vent clearing pressure.

In Figure 3.1, the maximum vent clearing pressure of [redacted] bar results for a reactor pressure of [redacted] bar and a valve opening time of [redacted] ms. The specification is based on this value.

Figure 3.3 shows the influence of an initial overpressure of 0.2 bar in the blowdown pipe. A clear reduction of the vent clearing pressure results from the lowering of the water level in the blowdown pipe caused by this overpressure.

### 3.2 Expected steady-state pressures

From the GKM measurements we can infer the steady-state pressures at the quencher to be expected in the plant. In Figure 3.4, the pressure to be expected for the KKB quencher is plotted as a function of the reactor pressure for the valve flow rate indicated by the manufacturer. For comparison we also note the pressure rise that would result with a [redacted] reduction of the quencher outlet area. The specification value for the maximum steady-state internal pressure is [redacted] bar.

Figure 3.5 combines the representation of Figure 3.4 into a curve in which the steady-state pressure is plotted as a function of the mass flow density relative to the total outlet area.

The effect of friction in the blowdown pipe is slight. For high flow rates, the pressure expected after the orifice plate which is inserted after the valve is only ca. [redacted] bar higher than just before the quencher inlet.

### 3.3 Measurement of the pressure

The pressures in the blowdown pipe are measured just after the orifice plate, sometimes also before that plate and just before the quencher inlet (Figure 1.3). Fast pressure transducers are used and the measurement values are recorded transiently.

## 4. Vertical impulse force during water expulsion

### 4.1 Expected values of the vertical impulse

The water accelerated after opening the valve in the blowdown pipe is deflected in the quencher from vertical to horizontal motion. Consequently, there is exerted on the nozzle a downward directed vertical force, equal in magnitude to the water's impulse, which is passed on from the blowdown pipe to the fixed point of the system. The non-steady motion of the water can be calculated with the vent clearing model described previously. The instantaneous impulse of the water can then be derived from it. The vertical force increases as the water accelerates and vanishes as soon as all the water has passed the spherical central body of the quencher.

Figure 4.1 shows the calculated maximum vertical force as a function of the reactor pressure and valve opening time. As in Section 3, the loss factor in the quencher was set equal to [redacted] Figure 4.2 shows clearly that this value has a distinct influence on the vertical force (as opposed to its effect on the clearing pressure). The expected loss factor is between [redacted] and [redacted].

Figure 4.3 shows the effect of an initial overpressure of [redacted] bar in the blowdown pipe, which causes a distinct reduction of the vertical force.

## 4.2 Measurement of the vertical impulse

The vertical impulse is measured in two different ways.

### 4.2.1 Strain measurement on the blowdown pipe

Figure 1.3 shows the positions of the strain gauges DS 1,2 arranged on the pipe in the longitudinal direction. These strain gauges detect the strains resulting from internal pressure, from temperature due to a heating of the inner wall and from the vertical impulse to be measured.

Figure 4.4 shows the longitudinal stress on the pipe due to an internal overpressure.

Since the temperature stresses on the outside of the pipe due to a temperature jump inside the pipe are practically proportional to that temperature jump, the representation can be limited to a normalized temperature jump of [redacted]°K. Figure 4.5 shows the temperature rise in the pipe, normalized in this way, for vent clearing times of [redacted] and [redacted] ms, it being assumed that the actual temperature corresponds to the saturated-steam temperature of the steam according to the occurring steam pressure. Figure 4.6 shows the time dependence of the stresses on the pipe's outer axis resulting from these temperature variations, according to the stress calculation described in /10/. The temperature variation from Figure 4.5 was approximated here by a staircase function with a step size of [redacted] ms.

Finally, Figure 4.7 shows the stress as a function of the vertical force to be measured.

### 4.2.2 Strain measurement on the restraining structure

A second measurement of the vertical impulse results from the strain gauges DS 24,25 (Figure 1.3) on the restraining structure. Figure 4.8 shows the stress on the vertical supports as a function of the vertical force to be measured.

## 5. Transverse force and torsional moment on the quencher during operation

In this Section we consider only those forces which arise from the operation of the quencher itself. Added to this are forces that occur when the adjacent quencher is in operation. These are discussed in Section 7. The total force results from the sum of these components.

### 5.1 Expected values of the transverse force on a quencher arm

The forces on the entire quencher measured in the GKM test stand were transposed in /5.11.12/ to the conditions present in the plant. For the specifications, the determination of the maximum transverse force on a quencher arm was based on the most unfavorable measurement value for the entire quencher. In dividing the force among the individual arms of the quencher, it was assumed that the total force is generated by only [redacted] arms. The division was done in such a manner that the most unfavorable transverse forces resulted for the individual arms.

This specification value for the transverse force is to be compared here with an expected value. Instead of the maximum value, we start out from a mean measured value smaller by a factor of [redacted]. Furthermore, it is assumed that only [redacted] of the force is generated by [redacted] arms. The remaining quarter results from the other two arms. In this way, the mean expected value corresponds to half the specification value. The following Table makes this clear.

| Type of operation | Expected mean transverse force on a quencher arm (static equivalent load) | Specified transverse force on a quencher arm (static equivalent load) |
|---|---|---|
| Clearing after opening the valve | See Fig. 5.1 | See Fig. 5.1 |
| Closing the valve | | |
| Intermittent condensation | KRAFTWERK UNION AG PROPRIETARY INFORMATION | |

The force application point lies in the middle of the quencher's hole array (lever arm to quencher center point: [redacted] m).

## 5.2 Measurement of transverse force and torsional moment

The transverse forces are determined by strain gauges on [redacted] arms of a quencher. The arms are each provided with two opposing strain gauges (DS 13/19 and DS 20/21) at a sufficient distance from the welds to the central ball (so that neither notch stresses in the weld seam nor strain impediments due to the ball have an effect) (Figure 1.4). In the transverse force measurement, associated strain-gauges are connected in a "difference" configuration so that symmetric loads are cancelled out in first approximation and only bending stresses are indicated. Figure 5.2 shows the stress at the position of the strain gauge as a function of the transverse force.

Since the transverse force is measured on only [redacted] quencher arms, the total transverse force and the total torsional moment must be deduced from the resultants that are determined. A pessimistic

[estimate of the] transverse force on the entire quencher is obtained by [redacted] the maximum resultants measured over the [redacted] instrumented arms. In so doing, it was already taken into consideration that a force can also be exerted on the central body by the flow processes. Still to be added then is the force from the thrust arrays from [redacted] arm bottoms /18/, which is to be determined by calculation, and, under certain circumstances, a transverse force in the circumferential direction when the adjacent quencher is actuated, which is determined separately (Section 7).

Likewise, we get a pessimistic torsional moment for the entire quencher by [redacted] the maximum resulting moment measured with the [redacted] instrumented arms. It should also be noted that a simultaneous occurrence of the maximum values of total transverse force and total moment can be ruled out. Rather, it is to be expected that one of the two quantities becomes small when the other reaches its maximum.

The transverse force represents only a small part of the load on the quencher arm. The symmetrical loads on the quencher, illustrated in Figures 5.3 and 5.4, are larger. Figure 5.3 shows the stresses due to internal pressure, whose expected value is given in Section 3, and Figure 5.4 shows the stresses on the outer fiber due to a temperature jump of [redacted]°K inside the arm /13/. The stresses are practically linearly dependent on the temperature jump. The maximum expected temperature jump is [redacted]°K.

The highest stresses occur in the weld seam between quencher arm and central ball. Figures 5.5 to 5.7 show the stresses on the quencher arm due to internal pressure, temperature jump and transverse force, as determined in /13/. In addition, we must still allow for a stress concentration factor in the weld seam, which according to /13/ is expected to be

Furthermore, it should also be noted that the quencher loads and their effect can also be judged by the displacement transducer $W_{D3}$ and the strain gauges DS 7, 8, 22, 23 provided on the bottom mount.

## 6. Pressure at the bottom and walls of the suppression chamber

### 6.1 Expected values during vent clearing

The air-water oscillations arising after the expulsion of air cause pressure amplitudes which have their maximum value near the quencher and decrease with increasing distance from the quencher. While the maximum value depends on the boundary conditions for the vent clearing process, a function independent of the maximum value is expected for the pressure decrease with distance. Therefore, it is appropriate to consider the peak value and the distribution separately. In a third subsection, statements are made concerning the superposition during the clearing of several quenchers.

#### 6.1.1 Maximum pressure amplitude near the quencher

The pressure amplitudes arising near the quencher after the clearing were investigated closely in the GKM test stand. The measurement results and the transposition of these magnitudes to the plant are illustrated in detail in /5/. Additional studies are contained in /6/. The transposition of the measured values from the test stand to the plant starts from the assumption that the oscillation process remains the same as long as the combinations of parameters that stimulate and influence the process remain constant. Table 2 makes it clear that both the parameter combination characterizing the expulsion of air (row 6) and also the parameters influencing the spreading of the air (rows 7 and 8) are transposed practically as constants. Therefore, the measurement results obtained in the test stand also represent the expected values for the hot tests.

According to model tank tests /6/, the pressure amplitudes at the bottom are only slightly dependent on the clearing pressure (in contrast to the plain-ended pipe) (Fig. 6.1). [redacted]

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[redacted]

With this dependence, the following pressure amplitudes relative to a unit clearing pressure of [redacted] bar can easily be converted to other clearing pressures corresponding to the expected values listed in Section 3.

Figure 6.2 shows expected upper values for the pressure amplitude as a function of water temperature. Typical values together with the associated parameters are:

| Clearing pressure bar | Water temperature °C | Max. pressure amplitude bar |
|---|---|---|
| [redacted] | [redacted] | [redacted] |
| [redacted] | [redacted] | [redacted] |

These amplitudes correspond to the highest values measured in the test stand. The considerable scatter band due to the differing amounts of damping during air expulsion also encompasses values up to [redacted] lower.

The rise of the pressure amplitudes with water temperature occurs because, corresponding to the state of saturation, the steam remains in the air bubble to an increasing degree, which then acts like an additional quantity of air and reinforces the air oscillations.

With an initial overpressure of [redacted] bar in the blowdown pipe, the pressure amplitudes are increased by [redacted] bar due to the additional quantity of air. A typical upper expected value is:

| Overpressure in the pipe | Clearing pressure | Water temperature | Max. pressure amplitude |
|---|---|---|---|
| bar | bar | °C | bar |
| [redacted] | [redacted] | [redacted] | [redacted] |

where the associated parameters have been recorded again. It should be pointed out that for an initial lowering of the water level in the blowdown pipe, clearing pressures different from those in the normal case are applicable (see Section 3).

6.1.2 Pressure distribution in the circumferential direction and in the vertical center section

Whereas in the preceding Section we discussed only the maximum

pressure amplitudes expected in the immediate vicinity of the quencher, we shall indicate here the decrease of this pressure with distance. It was shown in detail in /4/ how the air-water oscillation treated theoretically in /14/ can be applied to the conditions of the quencher. The fact that the laws derived for an infinitely large water volume are also valid, in principle, for the pool of the suppression chamber bounded by walls, could be demonstrated by the evaluation of KWW tests contained in /15/. According to that, the laws are almost fully applicable in the circumferential direction of the suppression chamber, but also in the vertical center section with a few restrictions.

Figure 6.3 shows the expected distribution of pressure amplitudes in the circumferential direction of the suppression chamber. The pressure distribution based on the stress analysis is illustrated for comparison in Figure 6.4.

The expected distribution in the vertical center section is plotted in Figure 6.5.

6.1.3 Superposition during the clearing of two quenchers

Throughout the entire operative range of the relief system, only clearly separated valves (never two adjacent valves) are actuated simultaneously in the plant. Furthermore, even for simultaneous actuation it is not to be expected that the clearing and the air oscillations proceed fully coherently at two quenchers. In order to investigate the superposition of the processes at two quenchers,

two immediately adjacent quenchers and also two widely separated quenchers are actuated simultaneously during the tests. The expected values illustrated in the following are based on the assumption that the processes proceed coherently and therefore represent an upper estimate.

Figure 6.6 shows the expected superposed pressure distribution for two closely adjacent quenchers. Unit distributions were assumed for the unperturbed individual distributions of the quenchers. The mutual raising of the maximum pressure amplitude (caused by a mutual interaction during the air expulsion phase, which is conceivable during the formation of the air oscillation, i.e., before the occurrence of the maximum amplitude) is considered to be [redacted]. The increase results from the following reasoning: The maximum pressure amplitude during the air expulsion phase is less than [redacted] of the later maximum value. At the position of the adjacent quencher, [redacted] of this is effective for the assumed undisturbed distribution (see Figure 6.6). But this is less than [redacted] of the maximum value. The maximum value is increased by this percentage.

Figure 6.6 shows further that no appreciable pressure drop from the maximum value occurs between the two quenchers, since the mutual interaction coincides in first approximation with the reaction of a wall between the two quenchers (reflection), which hinders a decrease of the pressure amplitude.

It is hardly conceivable that a quencher could have an appreciable effect beyond an adjacent vent being cleared simultaneously (except for the raising of the exit* pressure level at the adjacent quencher itself). Thus, the pressure decrease there is expected to follow the same (normalized) curve as that of the unperturbed individual distribution.

Figure 6.7 again shows the superposed distribution for closely adjacent quenchers - here in a representation normalized to 1.

Figure 6.8 compares the specified distribution with the pressure distribution expected for 2 simultaneously actuated quenchers separated from each other by 100°. The distribution curves agree with those of the unperturbed process at one quencher (see Figure 6.3). No appreciable influence of one quencher on the pressure amplitude of the other is to be anticipated, since the undisturbed pressure amplitude of the individual quencher has already decayed at this distance. Between the two quenchers it is expected that the higher value of the two individual distributions results.

## 6.2 Expected values during condensation

Thorough investigations of the oscillations occurring during condensation, based on GKM measurements, are presented in /4/.

*Translator's note: German word here could mean either "exit" or "initial".

According to them, stochastic pressure oscillations (noise) having an amplitude of

[redacted] bar

are expected in the pool during condensation with supercritical pressure ratio. According to the model measurements, peak amplitudes of

[redacted] bar

are not exceeded even in the vicinity of the quenchers.

During condensation with subcritical pressure ratio, pressure oscillations of uniform frequency and amplitude with

$\Delta p \leq$ [redacted] bar, n > [redacted]

can arise due to synchronization of the oscillation processes at the individual steam bubbles from the approximately [redacted] outlet openings of a quencher. These condensation oscillations are expected to decay according to the same distribution curves as for the air oscillations (Section 6.1).

During condensation with very small mass flows, the condensation process can become unstable. Then water enters and exits rhythmically at the quencher. Associated with this are intermittently excited pressure oscillations whose maximum total excursion, according to model measurements, does not exceed those of the uniform pressure oscillations.

### 6.3 Measurement of the pressure distribution

The positions of the transducers used to measure the maximum

pressures in the suppression chamber and the pressure distribution are shown in Figures 1.1 and 1.2. An angular range of 100° is covered in the circumferential direction. The pressure distribution in the vertical center section is measured primarily at 135° (position of quencher A). The pressures are recorded by fast transducers on strain-gauge base via carrier-frequency measuring amplifier.

## 7. Forces on internal fittings due to relief processes

The pressure oscillations during the clearing of a quencher cause forces not only on this quencher itself (Section 5) but also on the other internal fittings in the suppression chamber. In particular, we may mention here:

- an adjacent quencher,
- adjacent vent pipes or protective tubes,
- struts and
- ribs.

The loads on these components are described in more detail in /16,17/. The specification value applicable for the pressure difference in the circumferential direction over a protective tube down to a submergence of [redacted] m is [redacted]

These loads are measured by foil strain gauges. The measurement for the quencher has already been described in Section 5. To facilitate the evaluation, stress-load diagrams are given in Figures 7.1 to 7.3 for a protective tube (strain gauges 33/34 and 35/36), a strut (strain gauges 26/27) and the measuring rib (strain gauges 39-44).

8. Temperatures

The temperature in the blowdown pipe is measured between the valve and the downstream orifice plate, besides on a pipe also ca.[redacted]m above the water level * (Figure 1.3). It is expected that the temperature should correspond to the saturated-steam temperature of steam, both during the pressure build-up phase prior to the clearing and also during steady-state condensation.

In the annular gap between blowdown pipe and protective tube, the temperature is measured on a pipe both in the water region and also in the air region (Figure 1.3). The measurement values obtained here enable us to obtain information concerning the heating of the water and a possible evaporation during shutdown in the longer-lasting tests. Estimates may be found in the Appendix of /16/.

The operation of the quencher throughout the operative range of the relief system can be checked with the temperature measurement points in the hole array of the quencher (Figure 1.4) (the condensation should occur in the joint flow method ** with draw-off of water from the pool through the water path of the quencher). According to model measurement in the GKM test stand and in the model tank, a temperature lying below the boiling temperature

*Translator's note: The apparent ambiguity in this sentence mirrors a similar ambiguity in the original German: It is not clear whether 2 or 3 different measurements are being described. Inspection of the cited Figure 1.3 should clarify this.

**Tr. note: Literal translation of German "Mitstromverfahren".

prevails in the water paths as far as the middle of the hole array throughout the entire operative range of the quencher.

Extensive temperature measurements in the pool are being made in the vicinity of quencher B (Figures 1.1 and 1.2). It is expected that the deviations are no more than [redacted]°C.

In addition, it should be noted that the responding temperature measurement points are equipped with sheathed thermocouples having a diameter of 1.5 to 3.5 mm.

Table 1: Vent clearing and condensation tests
Status 1 July 1974
Tabelle 1: Freiblase- und Kondensationsversuche

Stand: 1.7.1974

[SEE NEXT PAGE FOR KEY]

| Vers.-Nr. 1 | Reaktordruck (bar) 2 | Abblasedauer 3 | Ventil-Nr. 4 | Wassertemp. °C 5 | Meßgruppe 6 | Bemerkungen 7 | |
|---|---|---|---|---|---|---|---|
| 1 | [redacted] | 1 min | B | 35° | E | | |
| 2 | | 10 s | A | " | D | | |
| 3 | | 10 s | B | " | S | [redacted] | 16 |
| 4 | | 10 s | B | " | S | | |
| 5 | | 10 s | A | " | D | | |
| 6 | | 10 s | A + B | " | D 1 | [redacted] | 17 |
| 7 | | 10 s | B | " | E | [redacted] | |
| 8 | | 10 s | B | " | E | | |
| 9 | | 10 s | A | " | D | | |
| 10 | | 10 s | B | " | D | [redacted] | |
| 11 | | 10 s | B | " | S | [redacted] | |
| 12 | | 5 s | A + C | " | D 2 | [redacted] | |
| 13 | | 5 s | A - B | " | D 1 | [redacted] | |
| 14 | | Abblasen bis auf 70 bar ca.45 s 9 | B | [redacted] 13 | D 3 | | |
| | | | | | | [redacted] | 18 |
| 15 | [redacted] | ca. 125 s | B | 14 [redacted] | N | [redacted] | |
| 16 | | ca. 3 min | B | 15 [redacted] | N | [redacted] | |
| 17 | | ca. 4,5 min | B | | N | [redacted] | |
| 18 | | ca. 4,5 min | B | | N | | |
| 18a | | 2 min | C wird f. 2 min zugeschaltet 10 | | N | [redacted] | |
| 19 | | ca. 10 min | B | | N | | |
| 19a | | ca. 3 min | A wird f. 3 min zugeschaltet 11 | | N | [redacted] | |
| 20 | | | B | | N | | |
| 20a | | ca. 4 min | C wird f. 4 min zugeschaltet 12 | [redacted] | N | | |

KEY FOR TABLE 1

1. Test no.
2. Reactor pressure
3. Blowdown duration
4. Valve no.
5. Water temperature
6. Measurement group
7. Remarks
8. Possibly 80
9. Blowdown to 70 bar
10. C is connected for 2 minutes
11. A is connected for 3 minutes
12. C is connected for 4 minutes
13. [redacted]
14. [redacted]
15. Increasing to
16. [redacted]
17. Double test
18. Holding pauses due to RPV

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Table....... 2

KKB relief valve tests
Pressure and temperature measurement points

Status 9/20/74

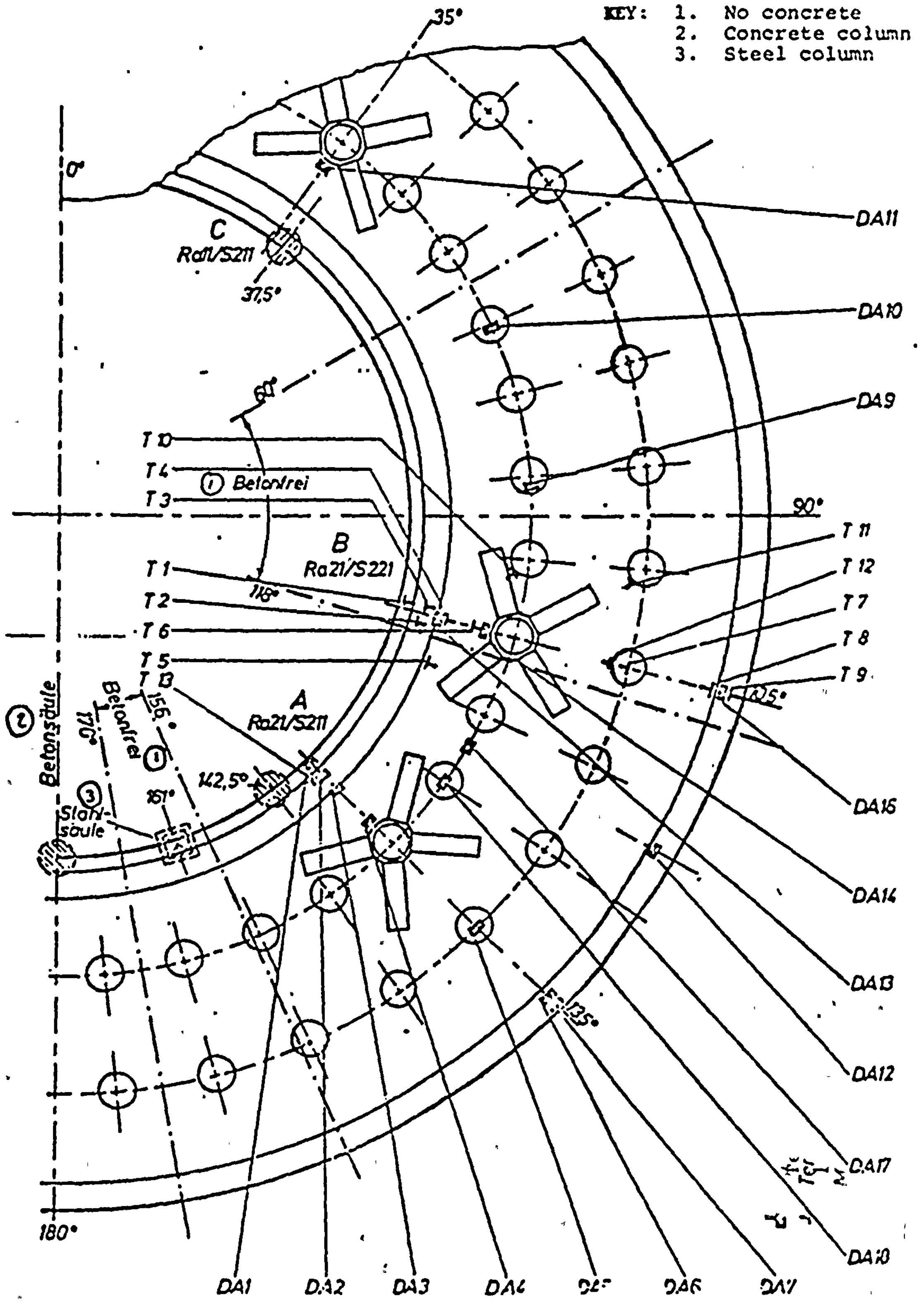
**KKB-Entlastungsventiltests**

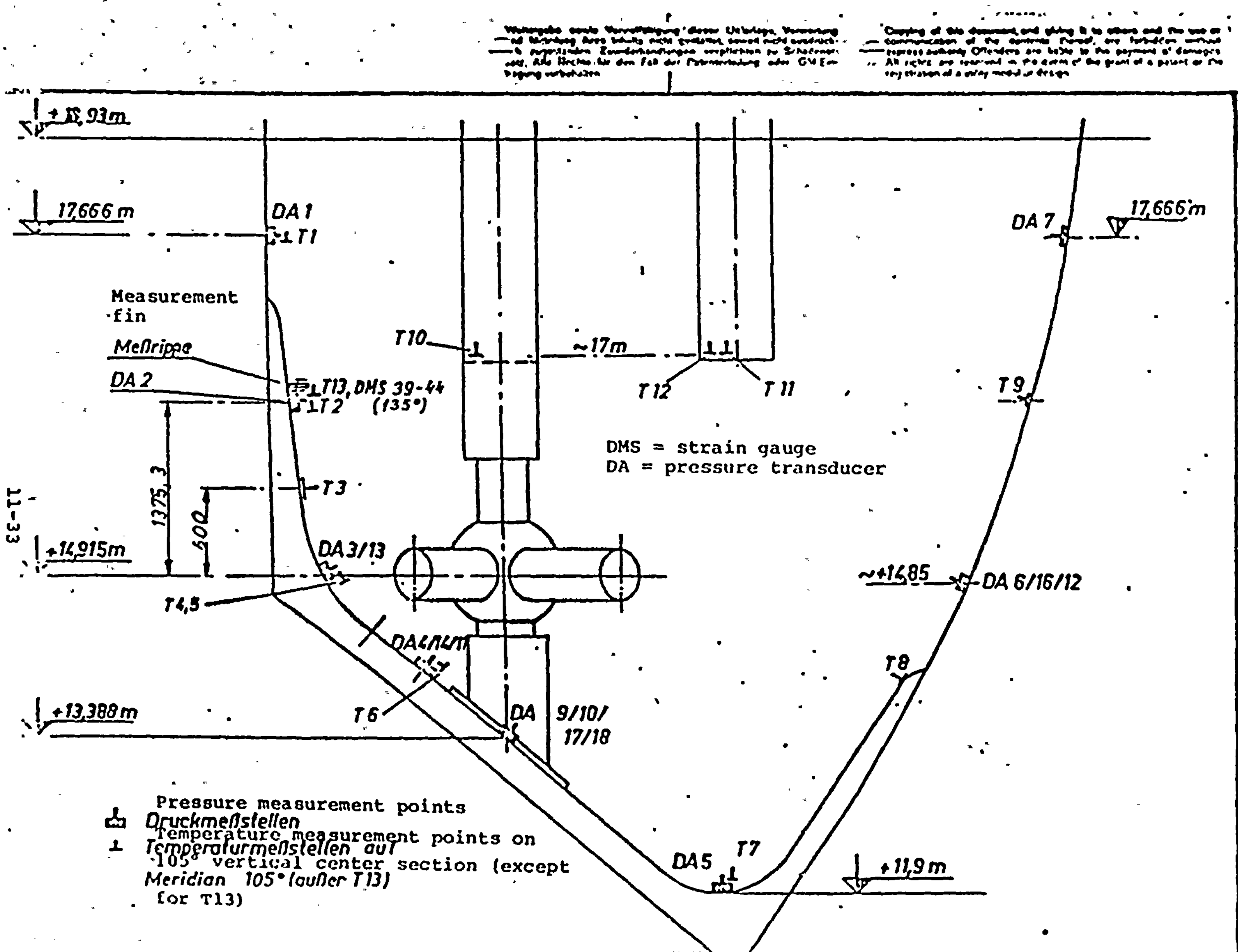
*Druck-und Temperaturmeßstellen*

Stand 20.9.74

Bild 1.1
Figure 1.1

KEY:
1. No concrete
2. Concrete column
3. Steel column






KKB relief valve tests

Pressure and temperature measurement points

# KKB-Entlastungsventiltests

Druck- und Temperaturmeßstellen

Status 9/20/
Stand: 20.9.

Figure 1.2
Bild 1.2

KRAFTWERK UNION AG PROPRIETARY INFORMATION

Figure....... 2.1

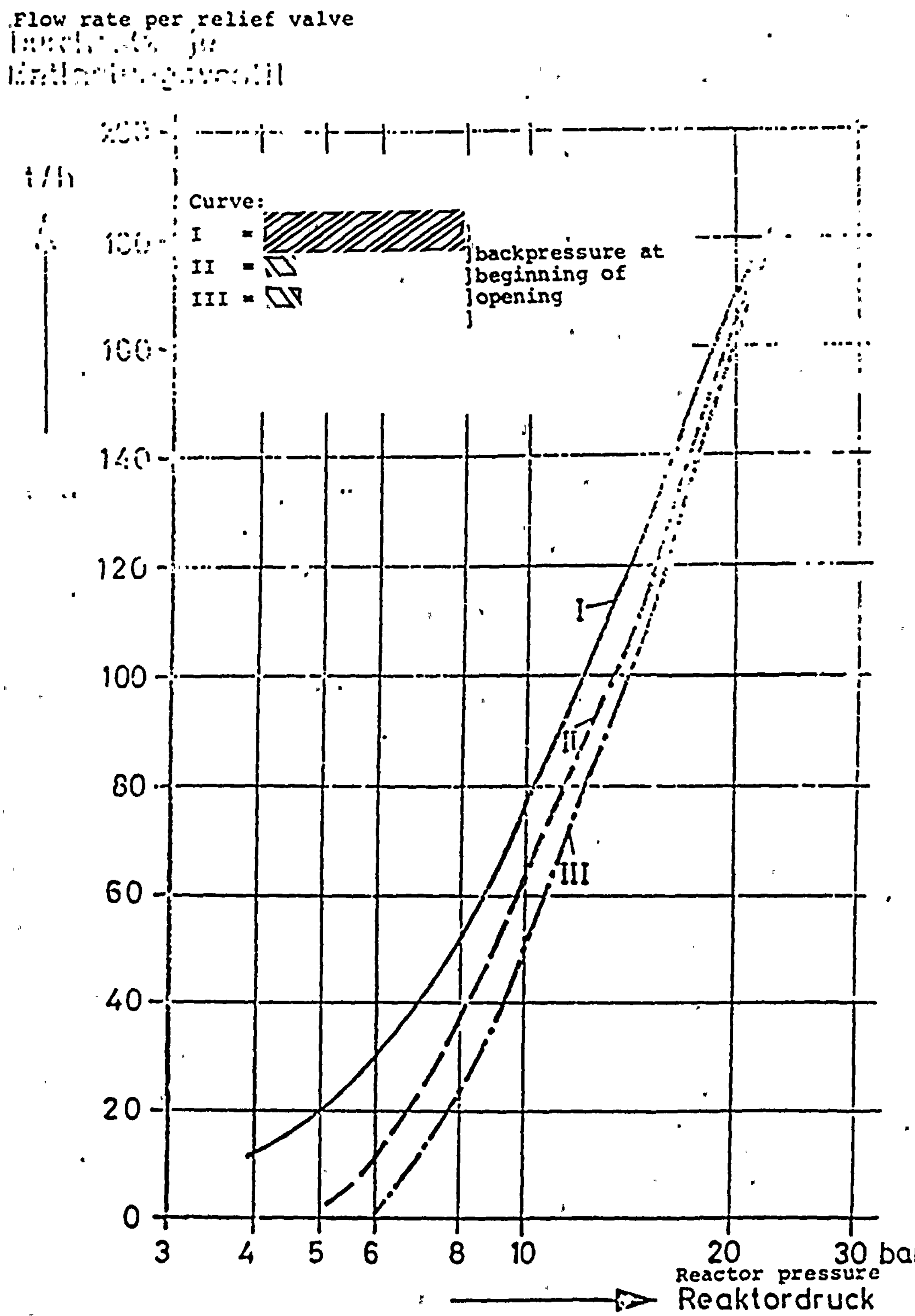



Bild 2.2 KKB:

Abblaseleistung bei abgesenktem Reaktordruck.

Figure 2.2 KKB
Blowdown capacity at lowered reactor pressure

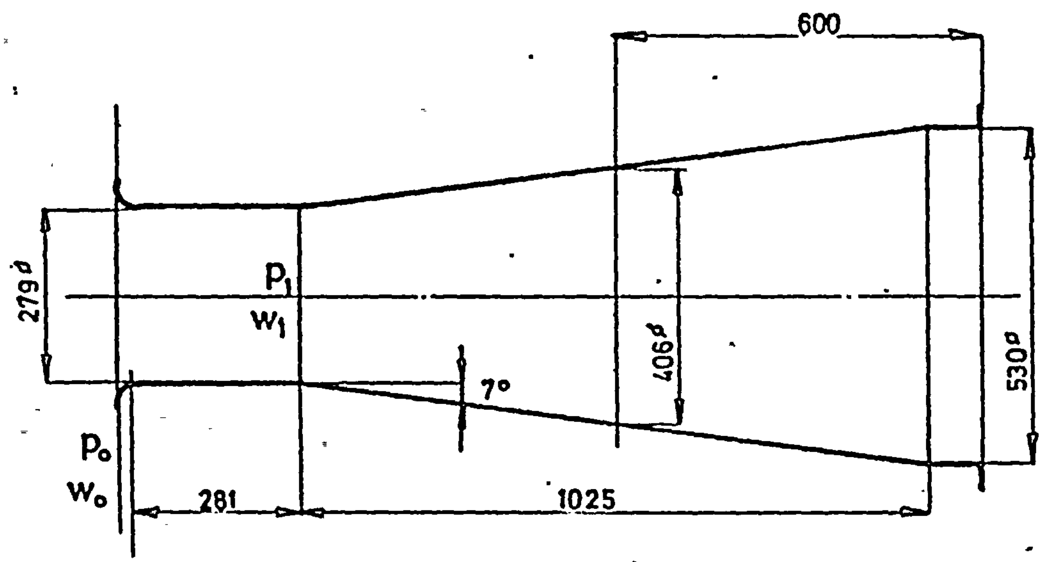
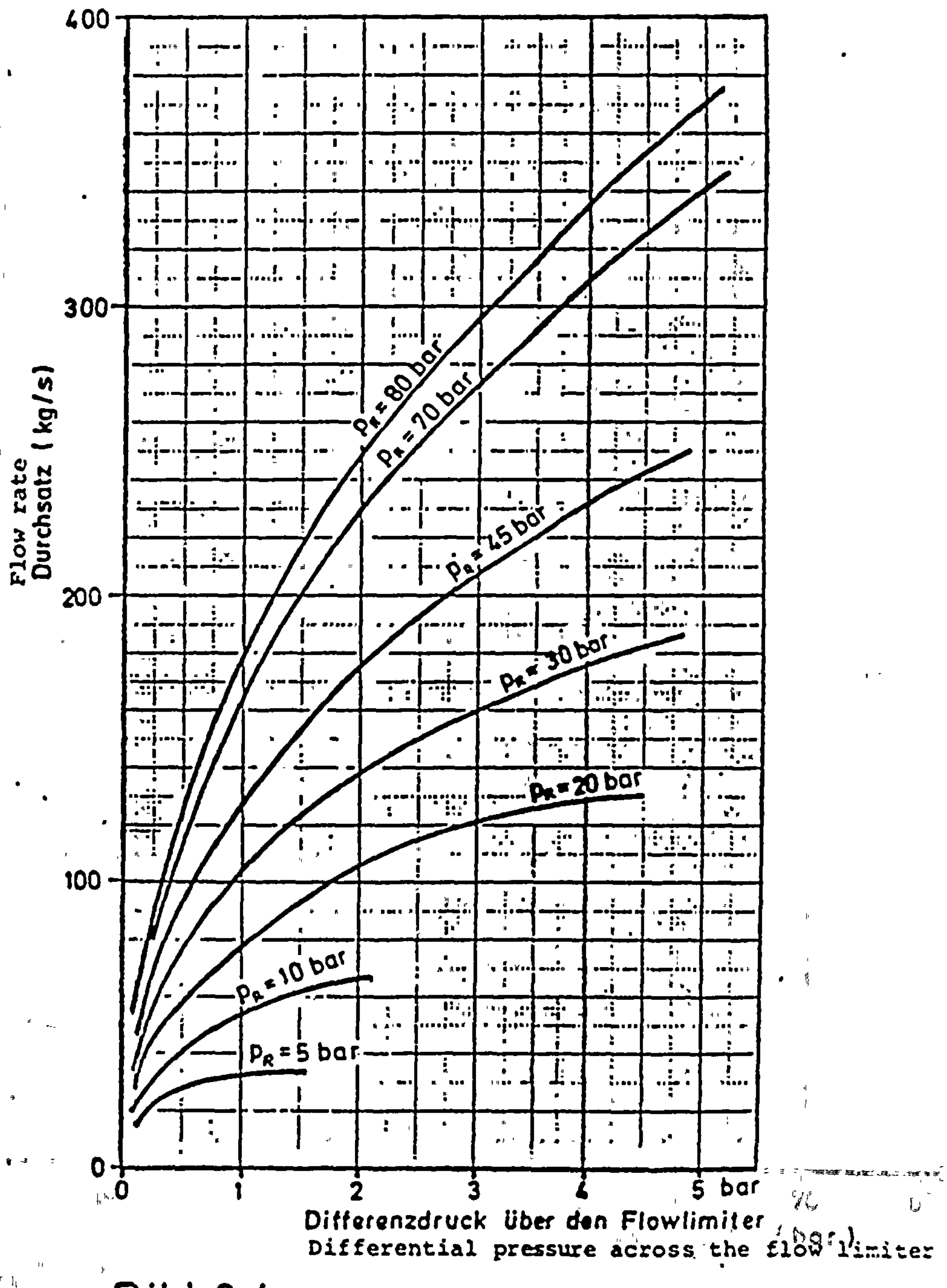



**Bild 2.3.**

KKB - Durchflußbegrenzer

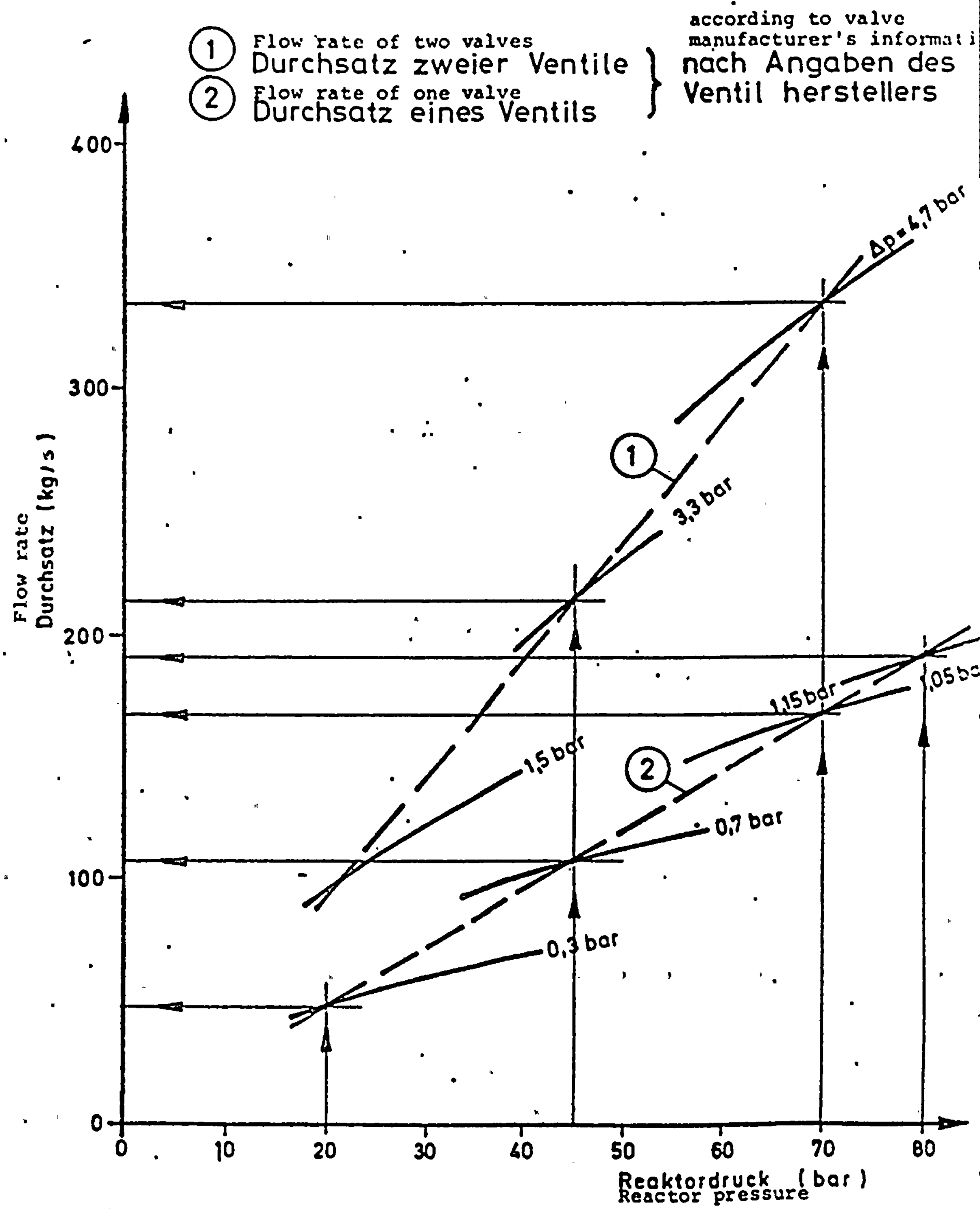
Figure 2.3
KKB - Flow limiter




## Bild 2.4:

KKB - Kennfeld des Durchflußbegrenzers

Figure 2.4
KKB - Characteristics of the flow limiter




## Bild 2.5:

KKB - Kennfeld des Durchflußbegrenzers

Figure 2.5
KKB - Characteristics of the flow limiter

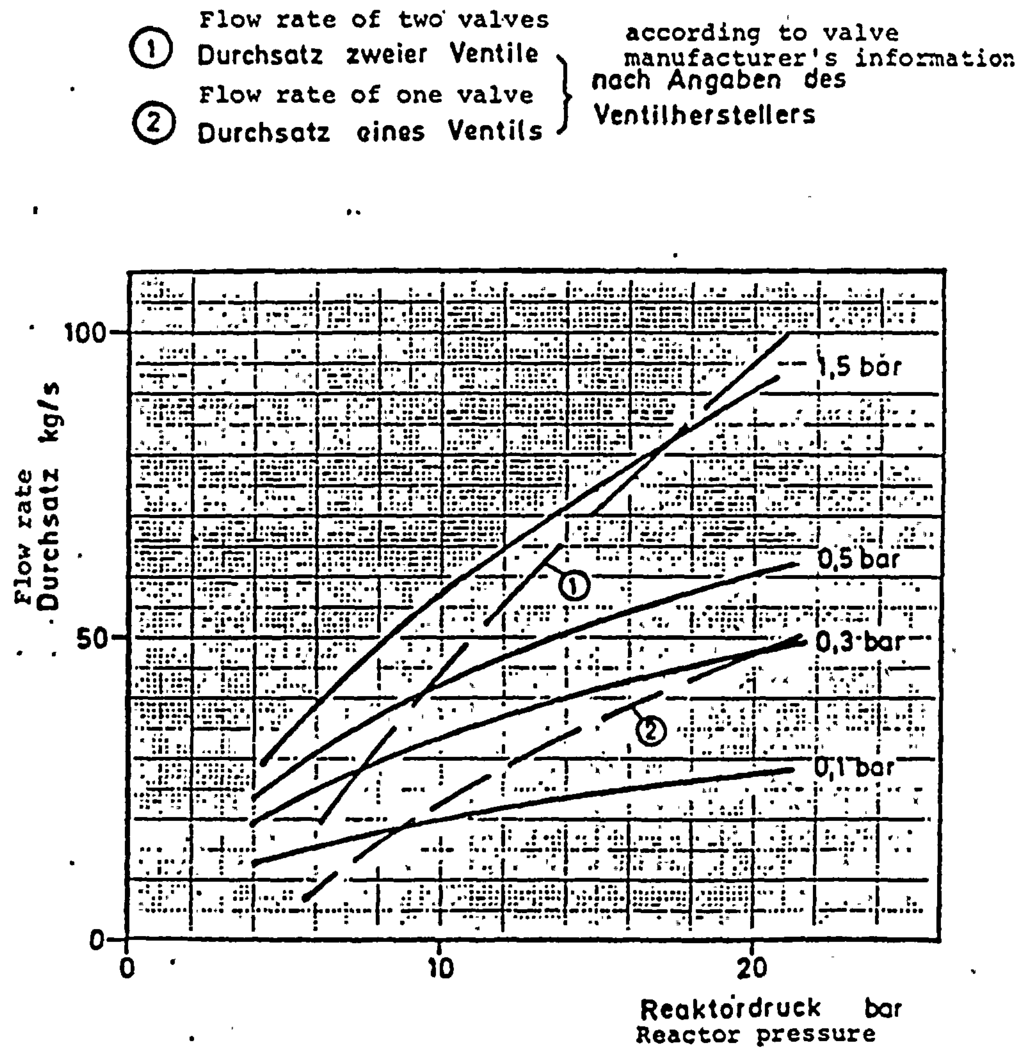



Bild 2.6:

KKB - Kennfeld des Durchflußbegrenzers

Figure 2.6
KKB - Characteristics of the flow limiter

KRAFTWERK UNION AG PROPRIETARY INFORMATION

Figure....... 3.1-6.6

11-40 - 11-58

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