Commonwealth Edison Company
Quad Cities Generating Station
22710 206th Avenue North
Cordova, IL 61242-9740
Tel 309-654-2241

ComEd

August 15, 2000

SVP-00-140

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Quad Cities Nuclear Power Station, Units 1 and 2
Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

Subject: Request for Additional Information Regarding Quad Cities remediation plan for welds susceptible to Intergranular Stress Corrosion Cracking (IGSCC)

Reference: Letter from J. P. Dimmette, Jr. (ComEd) to U.S. NRC "Response to NRC Request for Additional Information regarding Quad Cities Remediation Plan for Unit 1 IGSCC Susceptible Welds" dated November 3, 1999.

The purpose of this letter is to transmit our response to the Request for Additional Information (RAI) in the referenced correspondence. The attachments provide the requested information.

Should you have any questions concerning this letter, please contact Mr. C.C. Peterson at (309) 654-2241, extension 3609.

Respectfully,

George P. Barnes for

Joel P. Dimmette, Jr.
Site Vice President
Quad Cities Nuclear Power Station

Attachments:

Attachment A: Response to Request For Additional Information
Attachment B: IHSI Treatment for the 02AS-F8 weld
Attachment C: Minimum Surface Temperatures for Thermocouple #9

A001

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station

Question 1, stated,

Describe how the acceptance criterion of 555 degrees Fahrenheit for ΔT of cast stainless steel was determined. Provide the equation and parameters used in the evaluation. Identify the data source of σ_y (yield stress of cast stainless steel) used in the calculation and discuss its conservatism.

Response:

To assess the effectiveness of the IHSI treatment for the 02AS-F8 weld, the IHSI weld package for this weld, which is provided in Attachment A, was reviewed. The IHSI treatment essential parameters recorded in this package met the industry accepted limits specified in Reference 1. As described in Reference 2, one of the essential parameters is the through-wall ΔT, which was determined from the following equation.

$$\Delta T = \frac{2(1-\nu)}{E\alpha}(2\sigma_y)$$

Where σ_y = yield stress at room temperature
α = coefficient of thermal expansion
ΔT = differential temperature between the inside and outside surfaces
υ = Poisson's ratio

Using this equation, the minimum through-wall ΔT was determined to be 420 °F based on a yield stress of 36000 psi. Because of variations in piping and induction heating coil geometry, the IHSI application would have variations in the heating process and actual through-wall ΔT. To account for these variations and to provide margin over the minimum through-wall ΔT based on a mean yield stress the industry accepted minimum ΔT was set at 495 °F in Reference 1. As a conservative measure, the yield stress of cast stainless steel was compared to the yield stress used to determine the 495 °F ΔT. The yield stress for CF-8 and CF-8M cast stainless steel was obtained from Reference 3 for unaged material at room temperature. Because the service temperature of the valve cast material is below 550 °F and the valve had been in-service for less than 10 years when the IHSI treatment was performed, thermal embrittlement of the cast material is negligible. The unaged tensile properties were considered to be appropriate for evaluating the through-wall ΔT for the valve cast material. The average yield stress for the cast material is 38.2 ksi, which is almost a 10 % increase over the yield stress used to determine the 495 °F through-wall ΔT. Using this increase in yield stress for cast stainless steel material, the through-wall ΔT was increased by 10 % and conservatively rounded up to 555 °F.

Question 2, stated,

Describe how the field ΔT for the subject weld was determined and discuss the conservatism of the methodology and data used in the evaluation.

Response:

The minimum ΔT for the IHSI treatment of this weld is documented on page 7 of Attachment B. The ΔT was determined using the minimum outside surface temperature, measured at thermocouple #3, and the inside surface temperature. The inside surface temperature was conservatively determined from a heat transfer calculation based on the cooling water temperature of 60 °F and the flow velocity of 26000.0 gpm. The inside surface temperature was determined using the following equations, which were developed in Reference 2.

$$\Delta T = (T_o - T_i)$$

Where T_o = Pipe outside surface temperature
T_i = Pipe inside surface temperature

The inside pipe surface temperature was determined from the water temperature and flow rate using:

$$\Delta T = A(T_o - T_w)$$

Where

$$A = \frac{-1 + (2t/s) + e^{-(2t/s)}}{-1 + (2t/s) + e^{-(2t/s)} + \frac{2k_p}{s\,h}\left[1 - e^{-(2t/s)}\right]}$$

And

T_w = Water temperature
t = Pipe wall thickness
s = Heating depth
kp = Thermal conductivity of the pipe

The inside surface heat transfer co-efficient was determined from the following equation.

$$h = 0.023\frac{k_w}{d}\left[\frac{Ud}{v}\right]^{0.8} Pr^{0.4}$$

Where k_w = thermal conductivity of the water
d = Pipe inside diameter
U = Average cooling water velocity
v = Kinematic viscosity of cooling water
Pr = Prandtl number

As seen on page 7 of Attachment B, the heat transfer coefficient used to calculate the ΔT was based on a flow velocity of 15 ft/sec. The actual flow velocity was determined to be 16.32 ft/sec providing a conservative calculation of the inside pipe surface temperature.

Question 3, stated,

Provide the thermocouple data (temperature measurements from each thermocouple) from the IHSI of the subject weld. Also provide a sketch of the subject weld with connecting components including dimensions to show the location of each thermocouple and the corresponding local wall thickness.

Response:

A sketch of the thermocouple placement for the 02AS-F8 weld is provided on page 4 of Attachment B. It described the placement of three sets of three thermocouples. Each set is separated by 120° around the pipe circumference and consists of three thermocouples positioned along the pipe axis. One thermocouple is positioned on both sides of the weld, within 1/8" of the toe of the weld crown. The third thermocouple is positioned on the pipe 3" from the weld centerline. The strip chart of thermocouple temperature measurements available for the IHSI treatment of this weld does not include all of the thermocouple temperatures. The strip chart, presented in Attachment B, provides the temperature measurements with the exception of thermocouples 3 and 7. As documented on the IHSI heating record provided in Attachment B, the minimum surface temperature of 358 °C was recorded. The strip chart in Attachment C recorded the minimum surface temperature of 358 °C at thermocouple # 9. This thermocouple is located on the pipe, 3" from the weld centerline. The maximum surface temperature of 528 °C was recorded at thermocouple # 8, which is adjacent to the weld on the pipe. The temperatures recorded on the casting side of the weld were 385 °C and 460 °C at thermocouples 4 and 1 respectively. The recorded temperatures for the cast material were significantly greater than the minimum temperature recorded on the piping, 3" from the weld centerline. These recorded temperatures indicate that the piping temperatures increased from the outside of the coil toward the weld centerline. The minimum width of the heating zone for the weld is 3" based on the $0.75\sqrt{Rt}$ requirement defined in Reference 1. Based on these results, it is concluded that sufficient material was heated to temperatures in excess of that required for an acceptable IHSI treatment at this weld.

Question 4, stated,

Discuss and evaluate the effect of the shrinkage from the neighboring overlay repaired welds and loading from mechanical restraints such as pipe hangers and snubbers on the effectiveness of the IHSI treatment of weld 02AS-F8. Also discuss what effect would the reduced minimum outside surface temperature have on the acceptance criteria of minimum heating zone length and minimum heating distance from weld centerline.

Response:

The effect of weld overlay shrinkage has been assessed in Reference 4, and determined to be insignificant, i.e. less than 400 psi. This result is expected because the recirculation piping is supported to move with the reactor vessel using variable hangers and snubbers. Since these restraints would not resist pipe movement, the pipe stress changes caused by weld overlay shrinkage would be minimal. Snubber testing records for the pipe snubbers on this piping system had been reviewed and all the snubbers on the Loop A suction piping and recirculation pump met their operational test requirements. The only snubbers, which did not pass the operational test requirements, were on piping sufficiently remote from this weld that the calculated stress, Reference 5, is insignificant, i.e. less than 2000 psi. Based on this review, it is concluded that this weld has not been subjected to any unanticipated operating loads.

See the response to RAI (3) for the information on the minimum heating zone.

References:

1. EPRI NP-3375, "Induction Heating Stress Improvement," November 1983, General Electric Company.
2. EPRI NP-81-4-LD, "Residual Stress Improvement by Means of Induction Heating," March 1981, Ishikawajima-Harima Heavy Industries co., Inc.
3. NUREG/CR-4766 Volume 2, No. 2, "Long-Term Embrittlement of Cast Duplex Stainless Steels in LWR Systems – Semiannual Report April – September 1987," August 1989.
4. AR-00005152, "Document Acceptance of Shrinkage Associated with DCP 9600069, 98000292, 98000293, and 98000294," 1/28/00.
5. NDIT QDC-98-283, "Engineering Evaluation of Unit 1 Recirculation and RHR Shutdown Cooling Systems Due to Failed Snubbers 1-122 and 1-123," 11/17/98.

Attachment B, IHSI Treatment for the 02AS-F8 weld

IWP NO.: OC1-066

WELD NO.: 02AS-F8

IHSI WELD PACKAGE

FOR

QUAD CITIES UNIT 1 NUCLEAR POWER PLANT

Contents	Revision
o IWP Traveller	0
o Thermocouple Setting Instruction Sheet	N/A
o Coil Setting Instruction Sheet	N/A
o Operator's Master Checklist	N/A
o IHSI Heating Record	N/A

Prepared by: [redacted]

B.N. Thomas 4/5/84
NTC Test Engineer

Carl Weber
NTC Shift Supervisor

Issued by:

Jim Lamp
NTC Site Superintendent

W.E. Booth
NTC Field QA Supervisor

Date: 4-11-84

Q.A. REVIEW
DATE 5/19/84
SIG. [illegible]
TITLE QAE

REVIEWED
[illegible]
ANI
DATE 05-16-84

REVIEWED
[illegible]
QC DEPT.
DATE 5-14-84

[illegible] 4/12/84

QLH 4/12/84

IWP No: QC1-066 WELD No: 02AS-F8	IHSI WELD PACKAGE TRAVELLER	Page 1 Revision: 0

STEP No.	OPERATIONS	P.S. Oper./ Date	NTC Shift Sup./Date	NTC QA/ Date	CECo QA/QC Date	REMARKS
1	Install thermocouples in accordance with the Thermocouple Setting Instruction Sheet.	JL 4/20/84	JH 5-5-84	W ZAG 4-21-84		
2	Perform initial coil setting in accordance with the Coil Setting Instruction Sheet.		BN7 5-5-84			
3	Complete Items 1 through 26 of the Operator's Master Checklist (OMC).		BN7 5-5-84			
4	Verify cooling water flow through IHSI equipment in accordance with NUTECH Procedures document.		BN7 5-5-84			
5	Complete Items 27 through 34 of the Operator's Master Checklist (OMC).		[illegible] 5-5-84			
6	Clear the Heating Area of Unauthorized Personnel.		BN7 5-5-84			
7	Perform test heating in accordance with NUTECH Procedures Document. OMC Items 35 through 50.		BN7 5-5-84			

H = Hold Activity until signed off W = Notify Witness before proceeding

FINAL IHSI WELD PACKAGE APPROVAL: (To be completed after performance of IHSI treatment)

"The IWP has been reviewed for completeness and compliance with IHSI Procedure XCE 11 103, rev 6."

NTC SHIFT SUPERVISOR [signature] Date 5/8/84

NTC FIELD QA SUPERVISOR R.A. Green Date 5/8/84

nutech

IWP No: QC1-066

WELD No: 02AS-F8

IHSI WELD PACKAGE TRAVELLER
-continued-

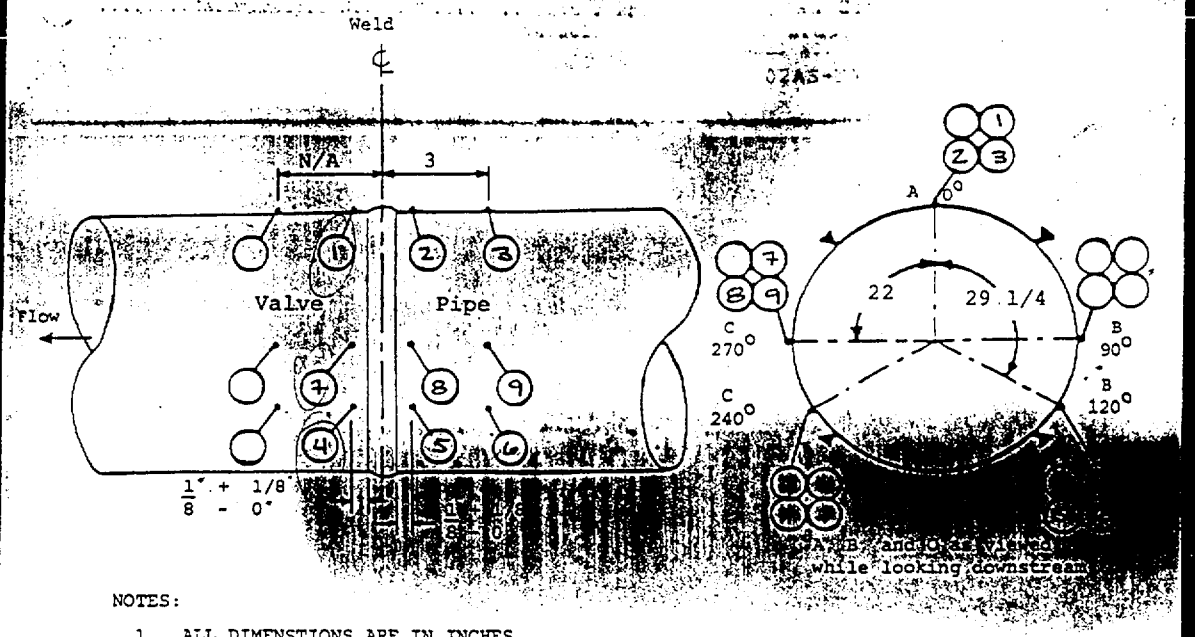
Page 2

Revision: 0

STEP No.	OPERATIONS	P.S. Oper./ Date	NTC Shift Sup./Date	NTC QA/ Date	CECo QA/QC Date	REMARKS
8	Clear the area of unauthorized personnel.		BW 5-5-84			
9	Perform regular heating and necessary coil adjustments in accordance with NUTECH Procedures Document. OMC Items 28 through 53		BW 5-5-84	W		Witnessed WB 5-05-84
10	Complete IHSI Heating Record with actual essential variables.		BW 5-5-84			
11	IHSI process is complete and accepted for this weld.		BW 5-5-84			
12	Remove thermocouples, polish and mark locations.					
13	CECo performs PT in accordance with CECo procedures.					By: 5-8-84
14	PT results accepted by CECo and attached to IWP.					

H = Hold Activity until signed off W = Notify Witness before proceeding

THERMOCOUPLE SETTING INSTRUCTION SHEET



NOTES:

1. ALL DIMENSTIONS ARE IN INCHES
2. THE TOLERANCE ON THERMOCOUPLE LOCATIONS ARE AS FOLLOWS UNLESS OTHERWISE SPECIFIED:

   AXIAL DIMENSION ± 1/8"

   CIRCUMFERENTIAL DIMENSION ± 1/4"
3. THE LOCATION OF THE 0° AZIMUTH (A) CAN BE ROTATED TO AVOID INTERFERENCES OR FOR CONVENIENCE.
4. AZIMUTHS B AND C MUST BE SEPARATED BY 150°

T/C's Installed By: Ted Keopp Date: 4/30/84 / 5/4/84
(C.D. Welder)

Randy L. Daum Date: 4/20/84

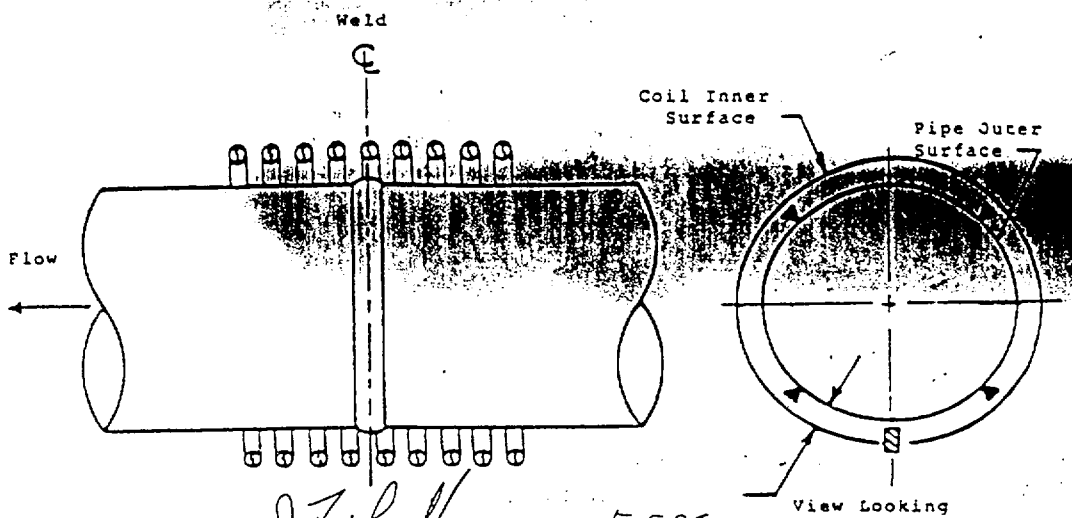
T/C's Inspected By: [signature] Date: 4-20-84

LEGEND ● .....Thermocouple ○ .....Thermocouple No.	▲ .....Guide Bolt RPV.....Reactor Pressure Vessel	PREPARED BY: B.N. Thomas PLANT: Quad Cities Unit 1 WELD NO: 02AS-F8

INITIAL COIL SETTING INSTRUCTION SHEET

CRITERIA:

1. Verify that coil (ID) to pipe (OD) is > 1/4".
2. Verify that coil is radially centered on weld within ± 1/4".
3. Verify that coil is axially centered on pipe during initial setting, or per coil manufacturer's design recommendation.
4. The tolerance on coil turn location is ± 1/8 from weld centerline unless otherwise specified below.



Inspected by: J. F. Smith Date: 5-5-87

Inspected by: N/A Date: _____

LEGEND:		IWP NO.: QC1-066
▲ ..... Guide Bolt	⊘ .....Coil Turn	WELD NO.: 02AS-P8
⊠ ..... Terminal		PLANT: Quad Cities Unit 1

A. DATE: 5-5-84
B. WELD #: 02AS-F8
C. COIL #: IHS 28" V-E
D. HEAT SITE: C

OPERATOR'S MASTER CHECKLIST (OMC)

Checklist Item	Operators Verification				Checklist Item	Operators Verification			
1. COMPLETE ITEMS A-D ABOVE.	✓	✓			28. HEAT SITE AREA CLEAR	✓	✓		
2. INDICATE HEAT RUN NUMBER	T_1	R_1			29. SITE BOX TO OPERATE	✓	✓		
3. INDICATE TEST HEAT OR REGULAR HEAT (T OR R)	T_1	R_1			30. GROUND RESET	✓	✓		
4. IF REHEAT, HAS COIL BEEN ADJUSTED? (YES OR NO)	N/A	N/A			31. MAIN BREAKER ON SCR LIGHTS ON	✓	✓		
5. START TIME	1448	1514			32. KVAR SETTING	4100	4100		
6. CONSOLE MANNED (INITIAL).	BNT	BNT			33. POWER RESET	✓	✓		
7. PHASOR MANNED (INITIAL)	Ken	Ken			34. DATA RECORDER ON	✓	✓		
8. WATER HEADER SELECTED (LETTER)	C	C			35. POWER ON (RECORD ACTUAL CLOCK TIME)	1511	1518		
9. HEADER INLET HOSE CONNECTED TO PUMP MANIFOLD (LETTER)	C	<			36. FREQUENCY KH_z (%)	97	97		
10. DISCONNECT ANY OTHER HEADER INLET HOSES	✓	✓			37. THERMOCOUPLES OPERATING	#7	#7		
11. START PUMP	✓	✓			38. VOLTS %	N/A	N/A		
12. LEAK CHECK PUMP AREA	✓	✓			39. CURRENT				
13. WATER AT HEAT STATION (GPM)/ PHASOR (GPM)	25/50	25/50			40. KW	20	35		
14. HEAT EXCHANGER WATER ON	✓	✓			41. OMEGA METER CUTOFF TEMP. °C (ACTUAL)	322	358		
15. HEINEMANN BREAKERS IN UP POSITION	✓	✓			42. POWER OFF	✓	✓		
16. LEAK CHECK POWER AREA HOSES	✓	✓			43. TRIP MAIN BREAKER	✓	✓		
17. COIL STATION MANNED (INITIAL)	Jimmy	Jimmy			44. IF TEST HEAT, MAX. PIPE TEMP. = 350°C	340	N/A		
18. COIL BOLTS TIGHT & NO OVERLAPPING WASHERS	✓	✓			45. IF REGULAR HEAT, MAX. PIPE TEMP. = 575°C	N/A	528		
19. WATER-COOLED CABLES INSULATED FROM METAL	✓	✓			46. IF REGULAR HEAT, HAS MINIMUM TIME BEEN REACHED (Y OR N)		YES		
20. CABLE CONNECTIONS TIGHT AND PAIRED AS BLK/BLK, RED/RED	✓	✓			47. RUN TIME (SEC.)	192.3	225.8		
21. HEAT SITE SELECTED (LETTER)	C	C			48. RECORDER OFF	✓	✓		
22. MAIN BREAKER IN HORIZONTAL TRIP POSITION	✓	✓			49. MAX. T/C TEMP BELOW 70°C	✓	✓		
23. CONTROL ON	✓	✓			50. SITE BOX TO SAFE	N/A	✓		
24. SITE BOX TO WATER TEST	✓	✓			51. CONTROL OFF		✓		
25. COIL FLOW OK	✓	✓			52. WATER PUMP OFF		✓		
26. COIL LEAK CHECK	✓	✓			53. HEAT EXCHANGER WATER OFF		✓		
27. REACTOR SYSTEM OR TEST STAND PIPE FLOW VERIFIED & RECORDED	✓	✓							

COMMENTS:

SHIFT SUPERVISOR B.N. Thomas 5-5-84

POWER SUPPLY OPERATOR B.N. Thomas 5-5-84

IHSI HEATING RECORD

Plant: Quad Cities Unit 1 Prepared by: B.R. Thomas

Weld ID: 02AS-F8 Checked by: [illegible]

Date: 4/5/84

Pipe Cooling Water

Flow Rate: Actual 26,000 GPM Instrument I.D. 1-260-11

Flow Velocity: Minimum 4.9 ft/s Actual Ft/s 16.32*
Pipe Wall Thickness 1.2"
Appendix J
Figure No. J-6*

Temperature: Maximum 104 °F 40 °C Actual 60 °F
Instrument I.D. 1-260-7

Process Variables

Heating Duration: Minimum 167.8 s Actual 225.8 s

Pipe Surface Temperature:

Minimum Peak	797 °F	425°C	Actual 358 °C	T/C# 3
Maximum Peak	1067 °F	575°C	Actual 528 °C	T/C# 8

Calculated Temperature Difference*

Heat Transfer Constant (A): 0.90+ Appendix I Figure No. I-20+

Temperature Difference Across Pipe Wall: ΔT Minimum $\geq$ 495°F (275°C)

$\Delta T = A \quad (T_o - T_w) =$ 0.90 (676 − 60) = 555°F

* Required only in the case that process variables (i.e. cooling water flow velocity, cooling water temperature and pipe surface temperature) fall outside the specified limits above.

Power Supply Operator B.R. Thomas 5-5-84

Calculation Checked By/Title [illegible] / Test Engineer

Date: 5/5/84

* velocity was extrapolated

\+ A value of 0.90 was conservatively arrived at using velocity = 15 ft/s.

[illegible] 4/12/84

[illegible] 4/12/84

RECORD OF SOLVENT REMOVABLE LIQUID PENETRANT EXAMINATION

Liquid Penetrant Procedure No. (CECo. SPPM) NDT-D Appendix "A" Rev. 5

STATION QCNPS UNIT 1 WORK REQUEST NO. Q 33365

SYSTEM Recirc DESCRIPTION OF INSPECTION: PT Thermocouple Removal Area

Reference DWG. No. ISI 103 SHT 2 OF 4 Rev. A

Material Type S/S Nom.Pipe Size(if Applic.) 28"

Weld No.(s) 02AS-F8

PreTest Visual: (1) Verify Surface is free from scale, slag, etc.
(2) Verify that there are no visual indications of unacceptable [redacted]

* IF SURFACE IS UNACCEPTABLE CONTACT CECO QUALITY CONTROL [redacted]

LIQUID PENETRANT EXAMINATION:

PENETRANT MATERIALS:

	TYPE	BATCH NO.	PURCH.ORDER NO.		TIME
Penetrant	SKC-HF/S	83K027	743238	Penetration	10 min
Penetrant Remover	SKC-NF	83M011	740192	Evaporation	5 min
Developer	SKD-NF	83J057	743238	Development	10 min
Pre-Exam Cleaner	SKC-NF	83M011	740192	Evaporation	5 min
Post-Exam Cleaner	SKC-NF	83M011	740192		

ACCEPTANCE CRITERIA: NDT-D-1 ADDENDUM Rev. 5

RESULTS: ACCEPT ☑ REJECT ☐	SKETCH:
NO INDICATIONS NOTED	

INSPECTOR Randall D Shuck COMPANY US Testing LEVEL II DATE 5-8-84

REVIEWED BY: QC [signature] DATE 5-8-84

QA [signature] DATE 5/8/84

AHI [signature] DATE 05/16/84

Attachment C, Minimum Surface Temperatures for Thermocouple #9

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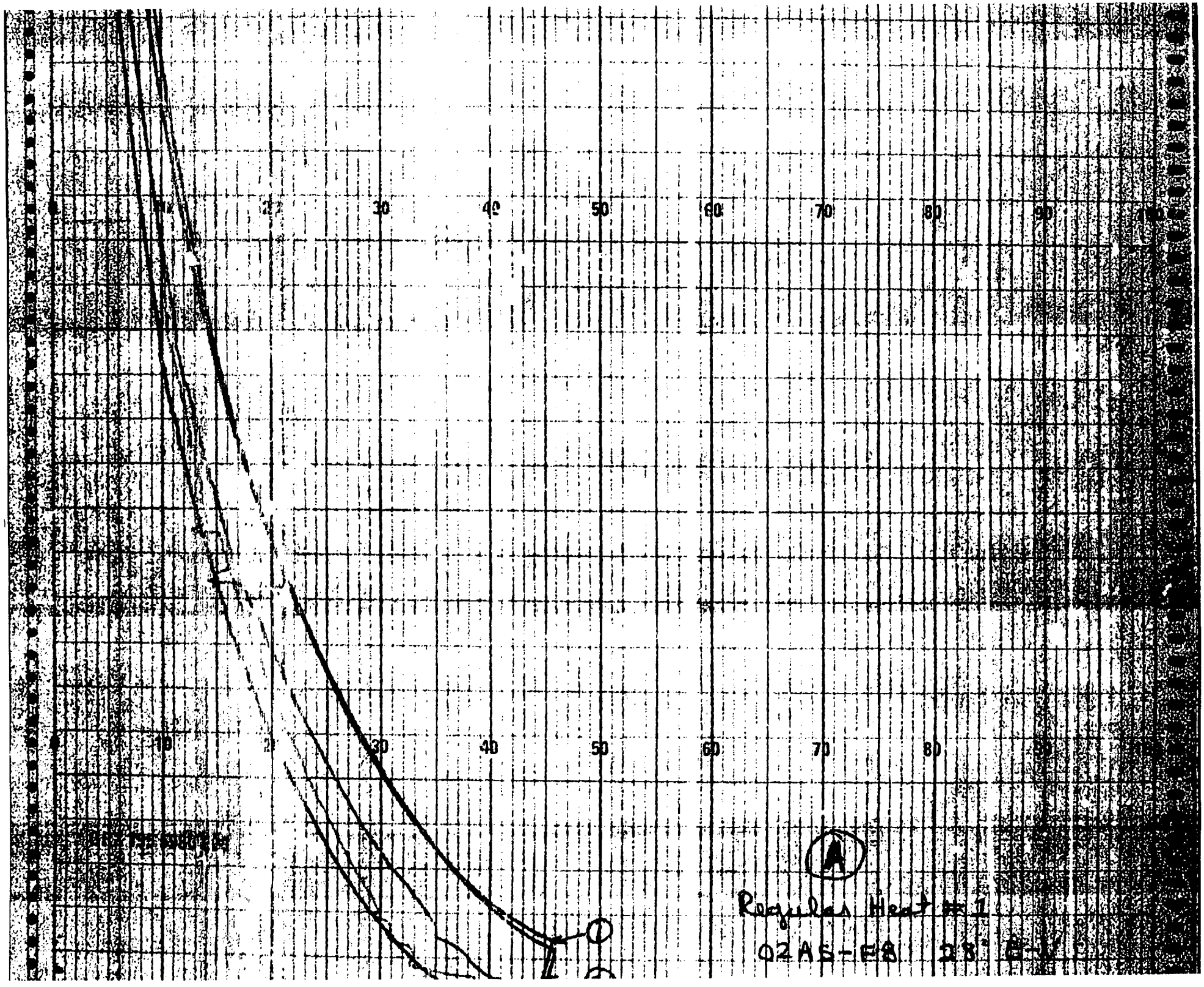

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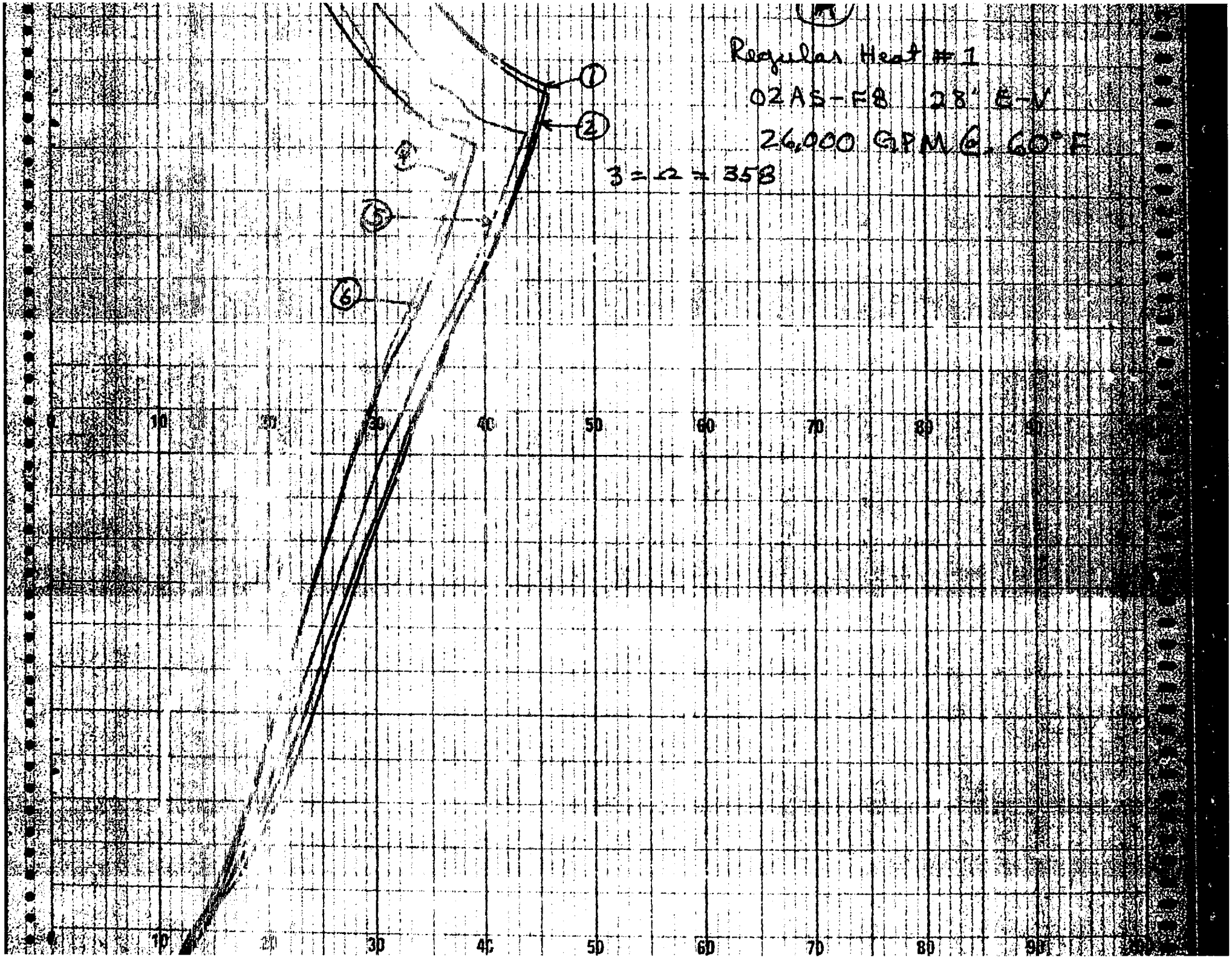
Regular Heat #1
02AS-E8 28" E-V
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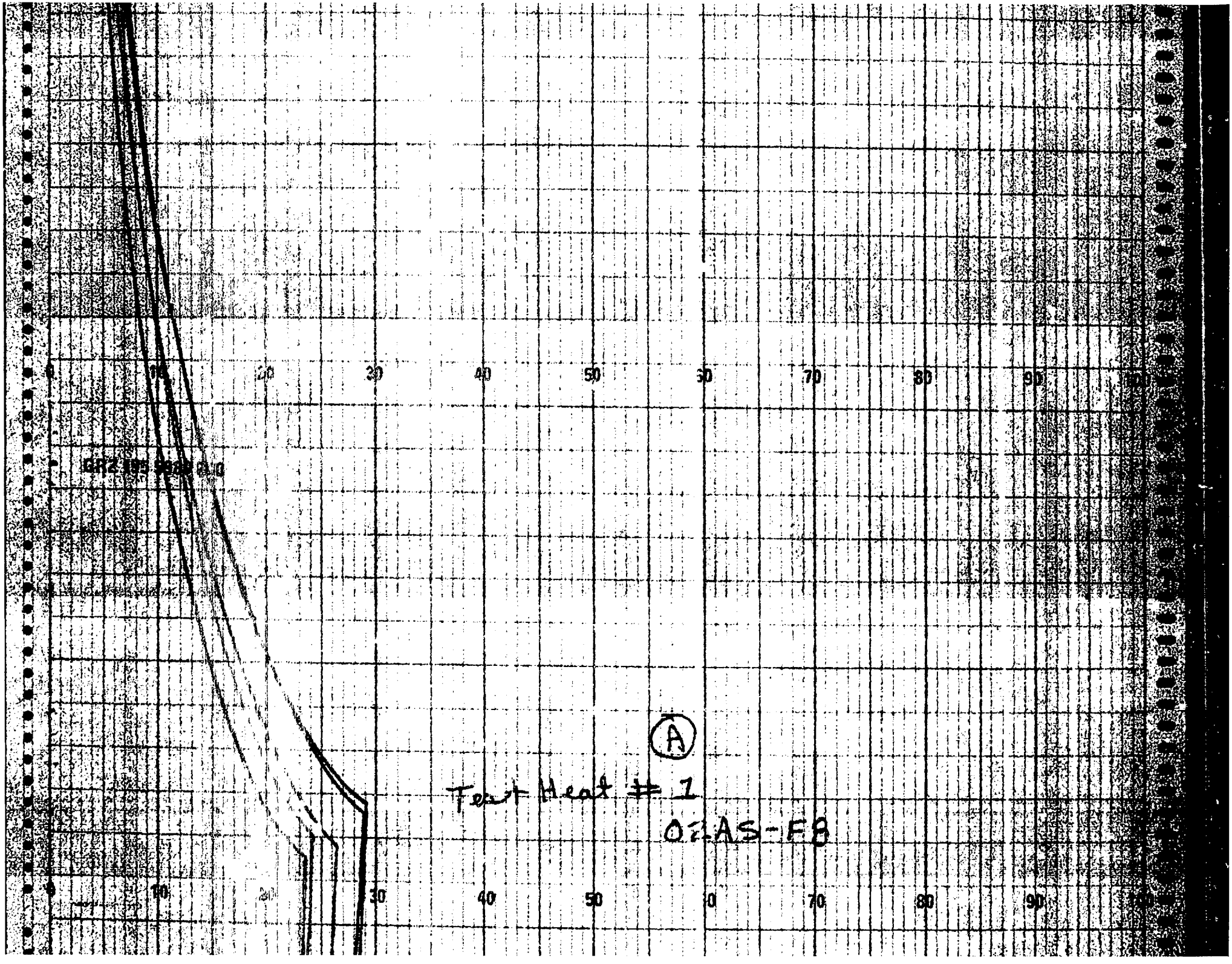

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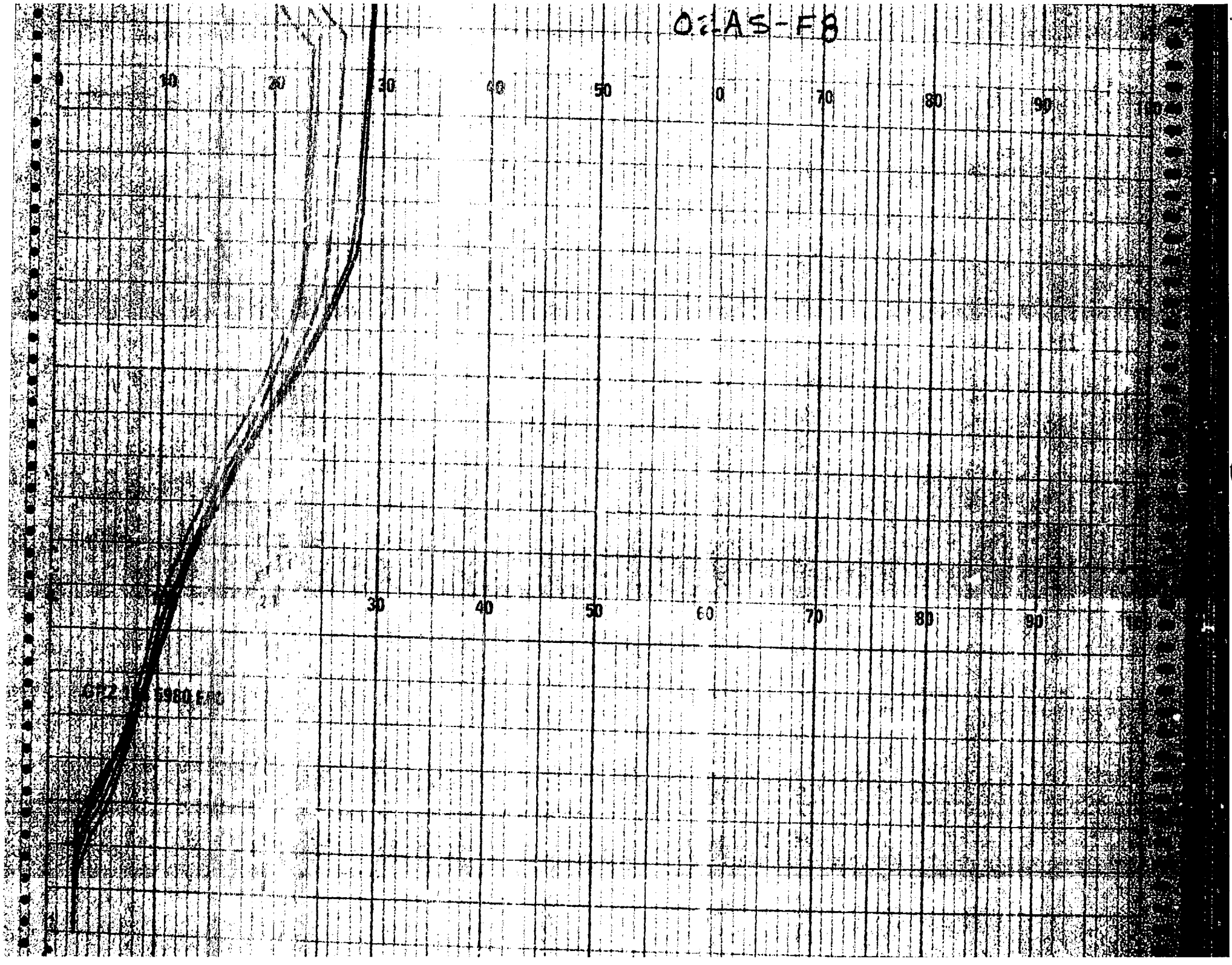
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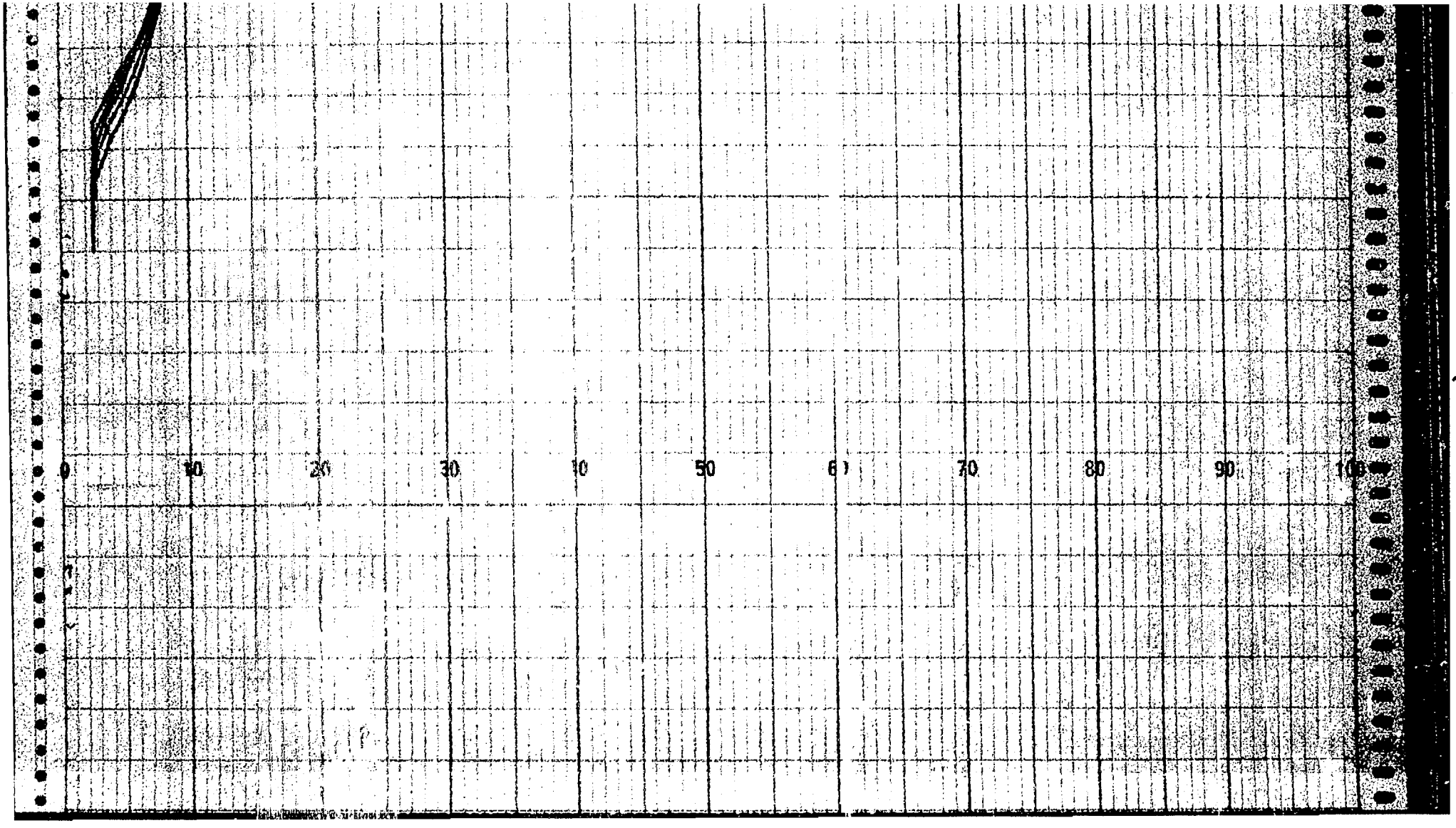
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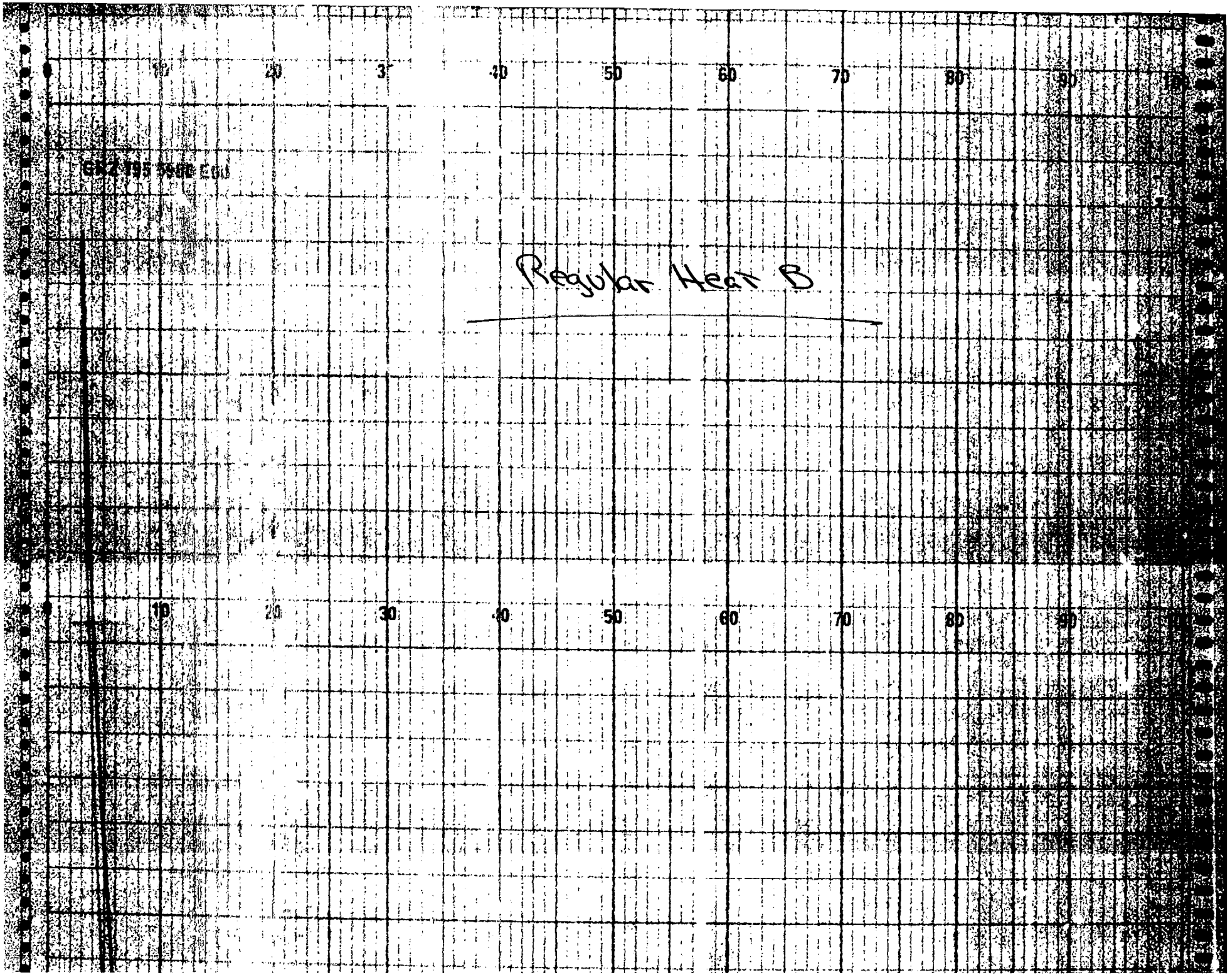
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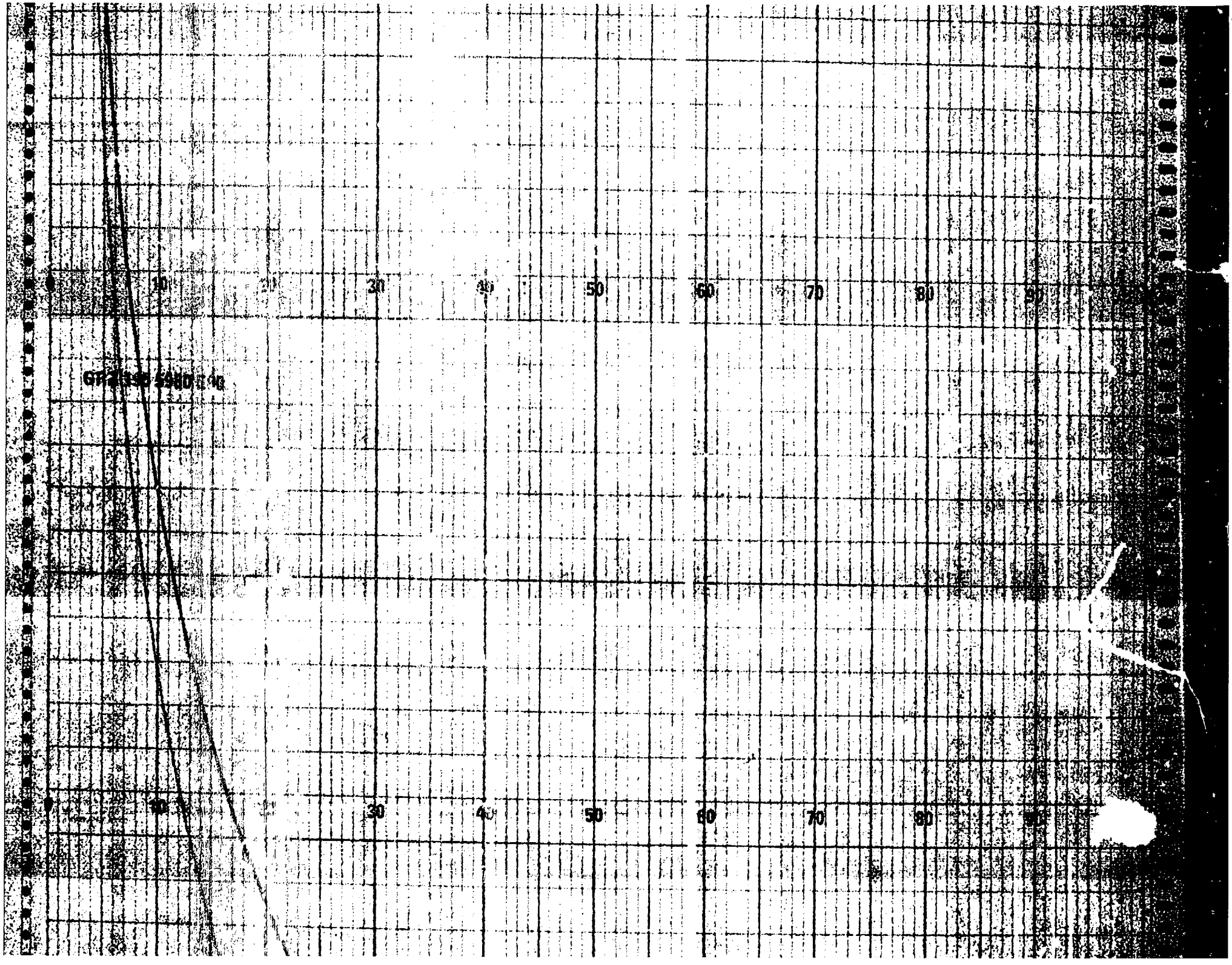
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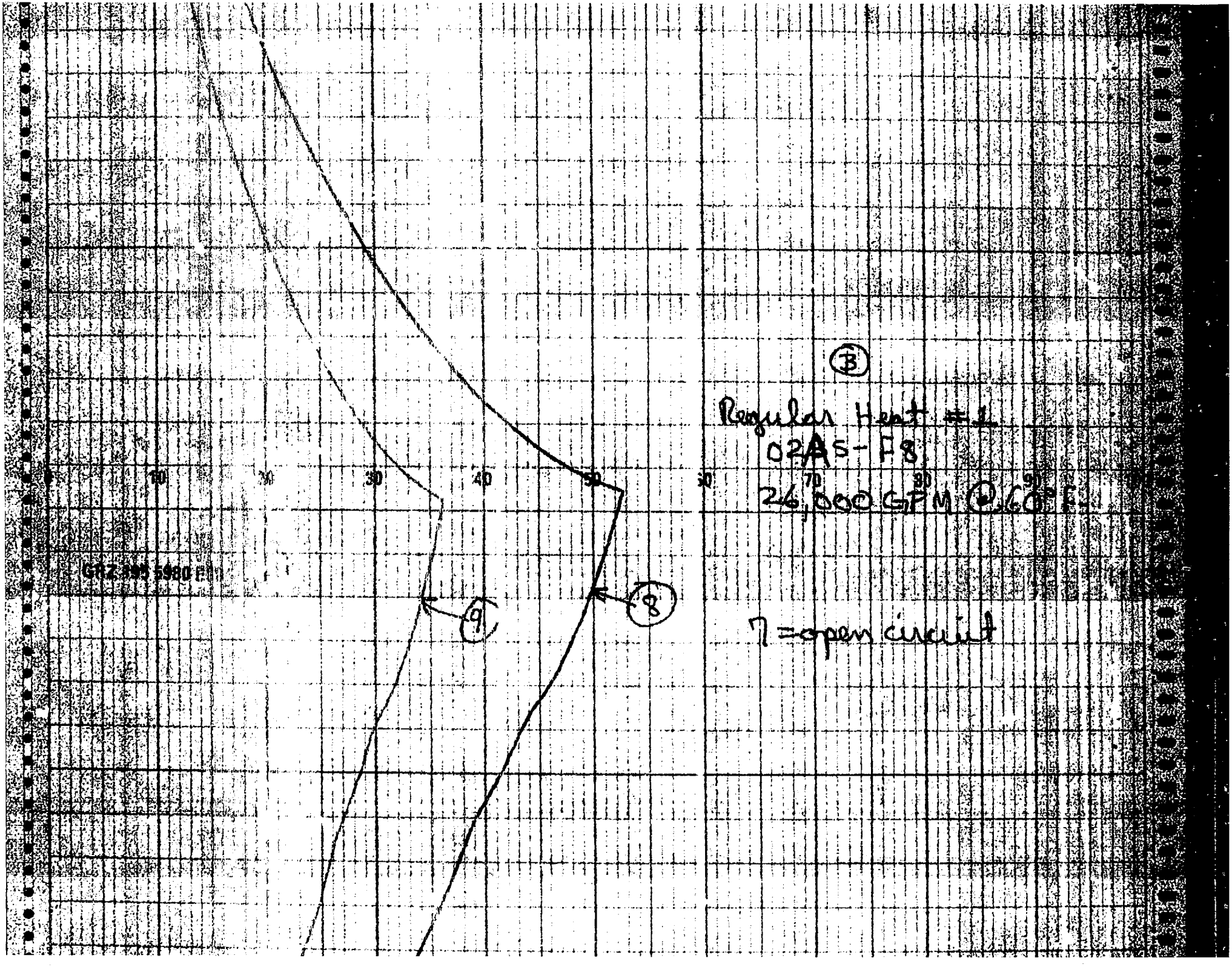

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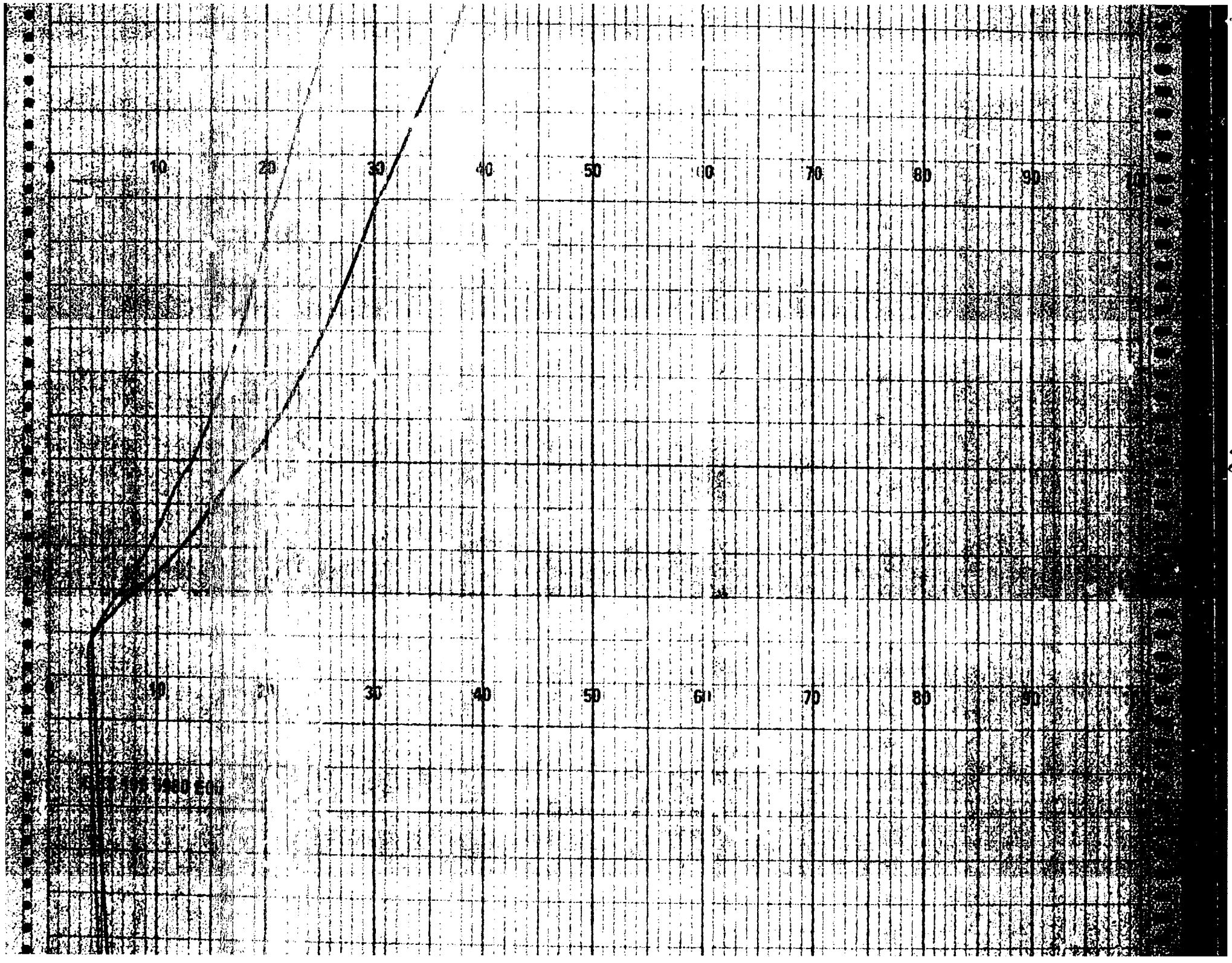
GRZ 395 5980
(B)
Regular Heat #1
02AS-F8
26,000 GPM @ 60°F
(9)
(8)
7 = open circuit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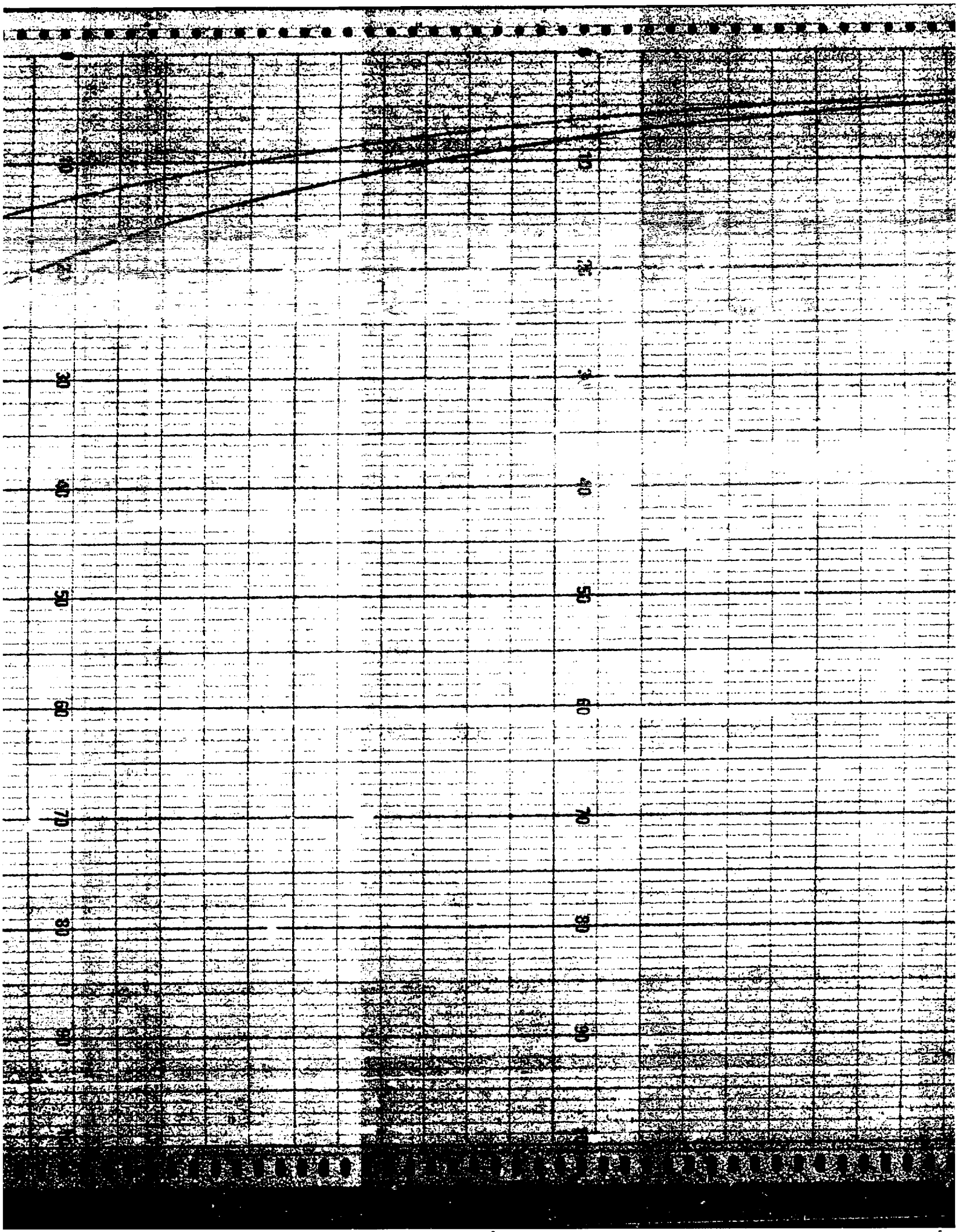

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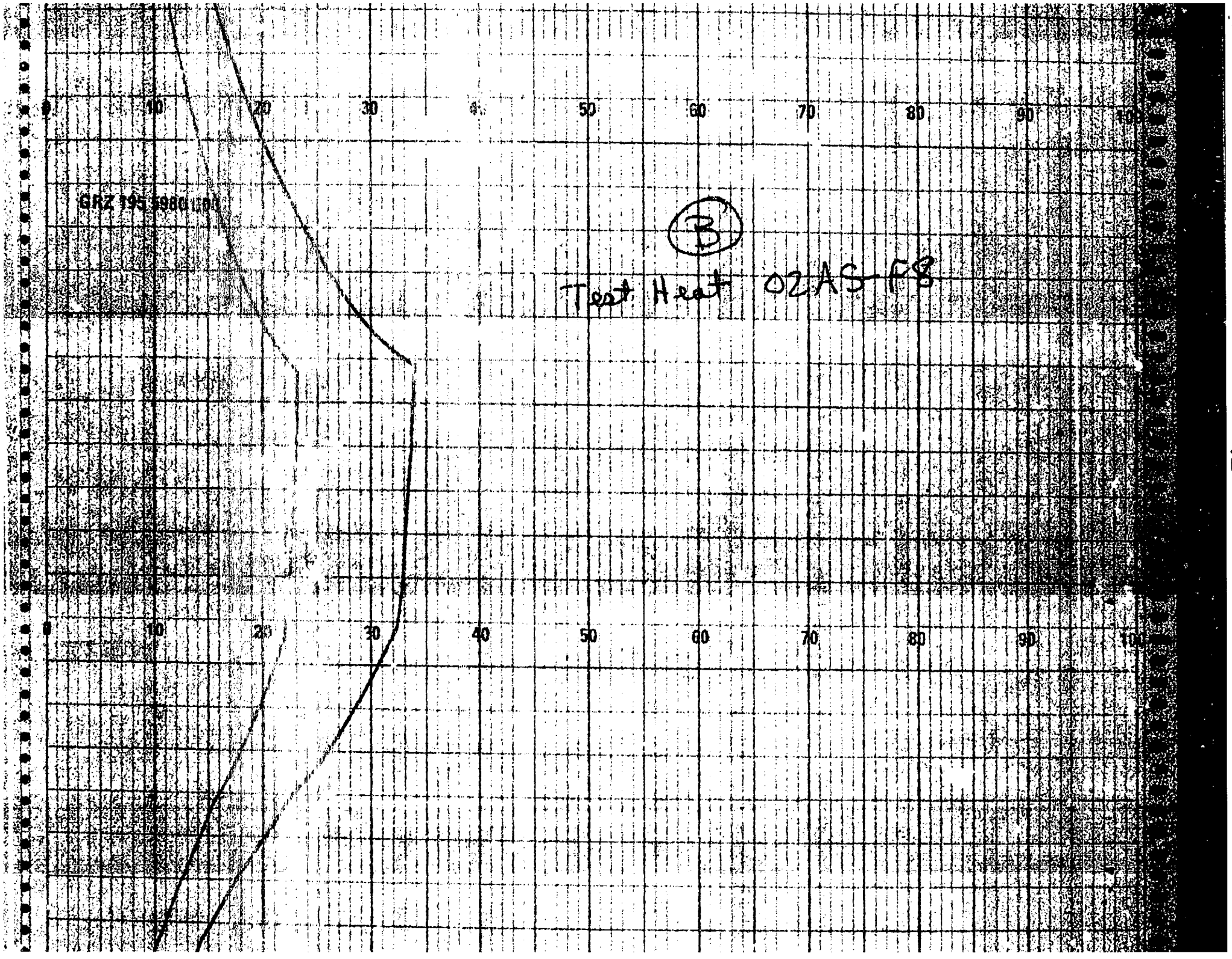
GRZ 195 5980 (20)
0
10
20
30
40
50
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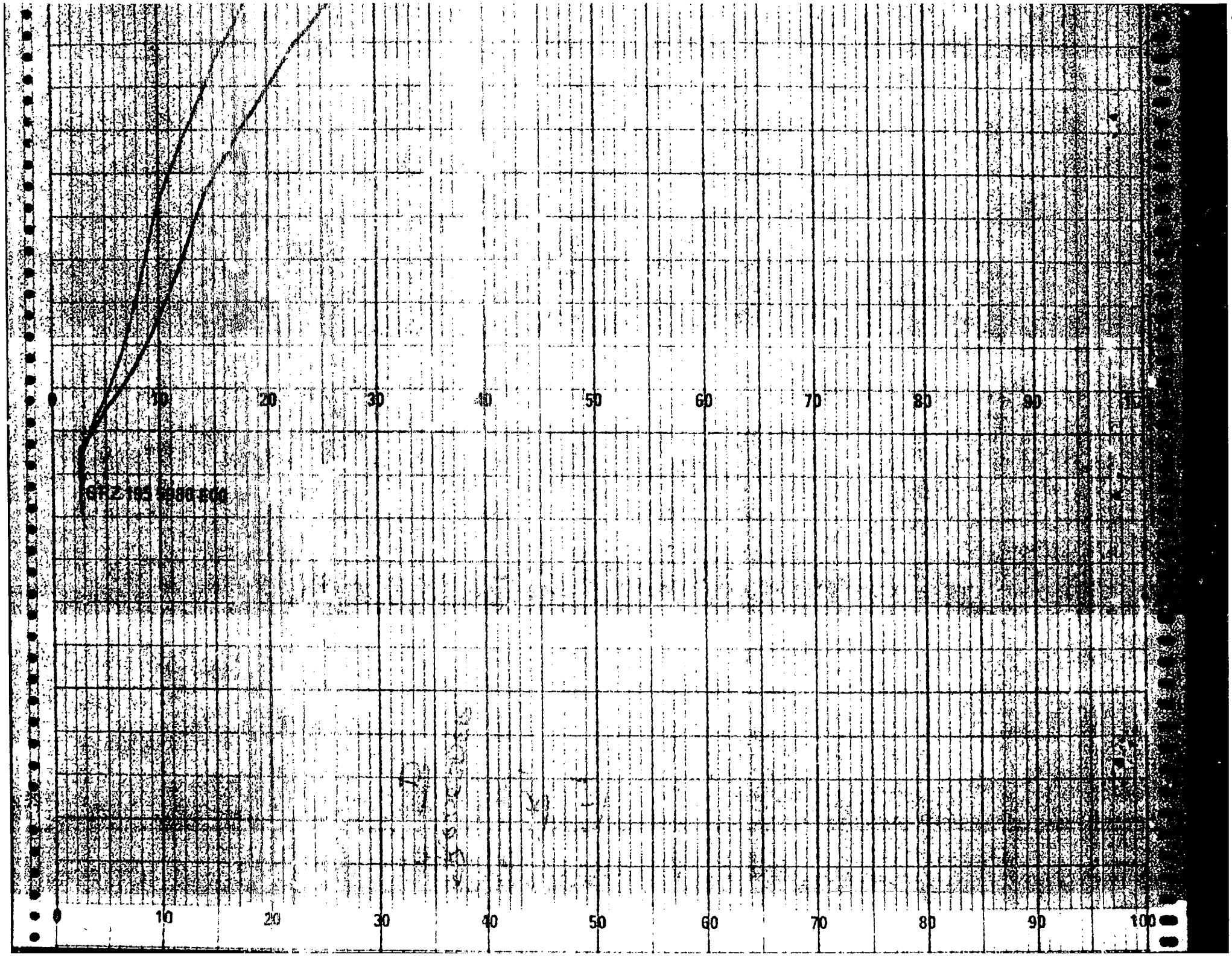
100
B
Test Heat 02AS-F8



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