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TOPICAL REPORT

GENERAL ELECTRIC VERTICAL INDUCTION MOTORS
INSIDE CONTAINMENT RECIRCULATION SPRAY PUMPS
FOR THE SURRY AND NORTH ANNA STATIONS
OF
VIRGINIA ELECTRIC POWER COMPANY

THIRD ADDITION TO COVER REBUILDING MOTORS USING NEW BEARINGS

Docket Nos. 50-280 and 50-281

M. W. Sheets
mw Sheets

July 23, 1979

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INDEX

1. PURPOSE

The purpose of this addendum is to show that the changes on Model 5K6319XJ1B to 5K6319XJ1C and 5K6319X1D, because of bearing failures and unavailability of some material, will not affect the qualification of these motors covered by Dockets 50-280 and 50-281 and the Topical Report on G. E. Vertical Induction Motors Inside Containment Recirculation Spray Pumps for Virginia Electric Power Company.

2. INTENT

The intent of this addendum is to show, through test and analysis that changes listed below will not affect qualification.

2.1 Change in bearing to a single row angular contact split inner ring bearing.

2.2 Addition of spacer rings to fill space in lower endshield housing where the single row angular contact split inner ring bearing is used.

2.3 The use of larger, double labyrinth seal at the outside of the lower endshield where the shaft leaves the motor to offset the enlargement of the diametric clearance where the shaft passes through the lower endshield to prevent rubbing of the shaft.

2.4 Change sealing materials at location where leads extend from the motor.

2.5 Added bearing thermocouple to lower bearing at lower end of motor.

3. HISTORY

The above motors were qualified by test in 1973 through testing. See Topical Report and Docket No. 50-280 and Docket No. 50-281.

At the time of the test, the test motor was subjected to a number of heat runs at General Electric San Jose and at Franklin Institute Research Laboratory before the motor was subjected to five temperature/pressure excursions similar to five loss of coolant postulated design basis events as required by IEEE 334-1971. Following the excursions, the motor was subjected to a post-accident test. During the test, no problems were noted. After the test, the motor was examined and no problems were noted. The bearings and grease were sent to the manufacturers for analysis. In all cases, the manufacturers concluded that the bearings were still usable. See Appendix A for a copy of the reports from the bearing and grease manufacturers and Appendix B for a summary from the Topical Report.

Following the above test, additional running tests were made on motors during the construction of the Surry Station. No problems were detected.

During the pump run-in test at North Anna No. 2, one motor, Model 5K6319XJ1B, S/N JJJ 919019, stalled. The motor was returned to General

Electric San Jose and a lower bearing failure was found. The bearing internal parts had frozen due to tightening up of the bearing parts. The motor was rebuilt and again failed. Again, the motor was returned to San Jose and again the problem was a lower bearing failure. After reviewing the failure and discussing the problem with the bearing manufacturers and the General Electric Laboratory, it was concluded that the failure was due to the bearing seizing due to the elimination of the internal bearing clearance due to low internal bearing clearance, shaft heating due to motor loading of the TEFC construction where the rotor heat is carried off by the shaft to a greater degree than other motor constructions and an accumulation of tolerances on the lower motors parts. See assembly drawing in Appendix C.

Further tests on four other motors were made on pumps with a thermocouple mounted against the outer race of the lower bearing. After running at least 24 hours with the pumps operating at the loaded condition, no problems were detected. The bearing temperatures showed no rapid rise, which would indicate a tightening of the bearing. Two of the tested motors were installed in the North Anna No. 1 Station and determined operable and will be rebuilt with the new construction when the plant is refueled. Appendix D shows the test results on the motors in North Anna No. 1.

While the above tests were conducted, work was done in General Electric San Jose to simulate the failure. After the failed motor was repaired, it was tested with two different double row bearings with different internal fits made by New Departure and Fafnir. The New Departure bearings with internal clearances of approximately .0004 in. tightened up under overloads similar to that seen in the failure, even when the endshield bearing housing diameter was increased to allow the bearing to grow more freely radially. Temperature rise was measured by a thermocouple on the outer race of the bearing. Bearings with looser internal clearances made by Fafnir (.0011") were also tested at San Jose on the rebuilt motor. No unusual change in bearing temperature was detected during both full load and overload tests on the motor with the Fafnir bearing.

Based on these results, the Fafnir bearing was installed in the two motors removed from Surry No. 1 and tested on pumps in the North Anna No. 2 Station. Both motors indicated bearing tightening due to excess temperature determined by the thermocouple during the pump load test. It was concluded that the difference in results from the San Jose General Electric test and the North Anna test was due to the fact that the motors at North Anna could have had tighter tolerances and that the test at North Anna was run with external pump thrust loading on the motor while the test at San Jose was run with no external thrust loading on the motor.

To use the double row bearing successfully on all motors, it was concluded that the bearing looseness must exceed .0011 in. which was the maximum looseness of the Fafnir bearings. MRC makes such a bearing but its delivery time would be four to eight months.

To solve the above problem, it was decided that the bearings must be changed to an MRC single row angular contact split inner ring bearing which is a standard stock item for MRC. This decision was based on past experience with the bearing over a period of 30 years in aircraft reciprocating engines, aircraft gas turbines, deep well pumps, and torque converters. This bearing has radial looseness in excess of .005 in., added thrust capacity, and axial endplay in the order of .020 in. The pumps used by VEPCO made by Bingham Willamette Pump Company will tolerate this endplay. The only change required in the construction to use the bearing is the addition of spacer rings because the new bearing is shorter than the double row bearing. Both bearings have the same outside and inside diameters.

To test the new bearing, a seven hour run was made at G. E. San Jose on a test motor built up from parts from the failed motor and the Franklin Institute Resarch Laboratory test motor. The motor was loaded with another 300 hp motor hung to simulate a 2700 lb. thrust load. The Stone & Webster specification for VEPCO indicated the thrust loading on the motor would be 1700 lb. continuous down. During the first ten minutes of full load test at 300 hp, a shaft rub occurred. This problem was corrected through realignment of test setup and reduced vibration. The vibration was reduced to below .002". The test was restarted and run at full load at 300 hp for six hours with no problems. Following the full-load run, the motor was run at an 8% overload for an additional 4 hours with no problems. Appendix D shows the test data.

The test motor was then sent to Bingham Willamette Pump Company where it was tested on a pump similar to that used by VEPCO. At the time of installation, it was noted that the radial clearance where the shaft passes through the lower endshield was only .003 in. The motor was run loaded on the pump for six hours at full load, with no problem. It was noted that the vibration was in excess of .005 in. The load was raised to an 8% overload and within one and one half hour, rubbing was detected where the shaft passed through the endshield. The motor was shut down and the slinger on the shaft at the lower endshield was removed and the overload test was continued. The motor ran succesfully for an additional six hours, plus four stops and starts, with no rapid rise in bearing temperature. Appendix E shows this test data.

When the motor was returned to General Electric San Jose and disassembled the shaft and endshield showed wear, but the bearing and grease looked in excellent shape. No bearing problems were noted as seen in the earlier failures where the bearing froze due to overheating due to the tightening of the bearing internal parts. It was concluded that the problem at Bingham Willamette was due to the close clearance where the shaft passes through the endshield (.003 in. radially), excess vibration (over .005 in.), the radial looseness of the bearing (over .005 in.) and the additional heating of the shaft at overload.

To eliminate the shaft to endshield problem, the endshield opening was increased to give a greater radial clearance around the shaft where it passes through the endshield. To minimize this increase, the labyrinth sealing slinger on the lower end of the endshield was made larger in diameter, one labyrinth surface was added, plus the labyrinth clearances were made closer and the distance the lab seal sits on the shaft was made longer. The overall length of the seal was increased at least .4 in. 'See the assembly in Appendix C. By making the above changes, the possibility of rubbing by the slinger to the endshield was eliminated, even with the tighter clearances.

The three Surry motors which were held in the Richmond General Electric Service Shop along with the 2 motors from North Anna No. 2 have been converted to the new design and all five, plus the motor rebuilt in San Jose have been successfully run-in at the North Anna installation. See Appendix G for test data.

The other two motors which tested successfully in the North Anna No. 1 Unit will be converted to the new bearing construction and retested in the North Anna site as indicated on Page 2.

The failed motor was rebuilt with the new bearing construction at General Electric San Jose, using parts from the failed motor and the Franklin Institute Research Laboratory motor. Upon checking the stator from the failed motor at an 80% of NEMA AC high potential test (1536 volts) the stator failed. This failure was attributed to the fact that this motor had gone through a stall during one of the bearing failures. The stator was rewound for the rebuilt motor and tested at the NEMA AC high potential test of [2 (460) + 1000 V] = 1920 volts.

All the other motors which were converted to the new bearing construction have successfully passed the 1536 volt high potential test.

No further problems are expected from the new bearing construction because the test motor with the new bearing construction ran through full load tests, both at San Jose and Bingham Willamette Pump Company, without problems, with the tighter shaft to endshield clearances. Actually the motor ran through two of the three overloads with no problems. The opening of the endshield will give added safety factor to the design. Further proof of the new design is the 6 successful run-in tests run on the 6 different motors in the North Anna facility.

Appendix H gives a list of the eight motors used in the Surry and North Anna Stations and shows the construction of each, plus reference to the tests run on each motor.

4. QUALIFICATION

This section of the Addendum gives data to show that the qualification made in 1973 will not be affected by the changes made in the motor discussed above. To show the effects on qualification, the following data is presented.

4.1 Single Row Angular Contact Split Inner Ring Bearing.

The new MRC 9218 single row angular contact split inner ring lower thrust bearing will not affect qualification because it is ball bearing like the double row ball bearing used in the test motor during qualification. The double row bearing operated through the qualification test and was still usable at the end of the test. See letters from the bearing and grease manufacturers in Appendix A. Both the 9218 and the double row bearings are locked in this motor construction, can carry thrust in both direction, and have equal protection with reference to contaminants entering the bearing during the qualification test. Actually, the MRC 9218 bearing will carry more thrust and, because of its cage construction, can give better protection against contaminants entering the bearing. The only part of the qualification that could be affected is the seismic. The new bearing has greater radial clearance and internal endplay than the double row bearing. The endplay will be no problem because the rotor weight will hold the bearing down during running and starting.

The MRC 9200 series single row angular contact split inner ring bearing is similar to the 7200 series angular contact bearing used in high thrust vertical motors in respect to radial clearance and internal endplay. MRC indicates that when the endplay is taken up by the rotor weight, the split inner ring bearing has better contact and less looseness than the 7200 series angular contact bearing. Also, MRC uses both the 7200 and the 9200 series in tandem. To do this, the radial looseness of the bearings must be similar. The 7200 series angular contact bearing has been seismically tested in a 1250 hp Class IE motor for the General Electric Nuclear Energy Division. During the test, the angular contact bearing saw g loading in the order of 9g. Based on the results of the test, the MRC 9218 single row angular contact split inner ring bearing will not be affected by the .42 g requirement which the original motor was subjected to during the qualification test. Appendix I gives a copy of the letter from MRC covering the bearing capacity and the comparison to the 7200 series angular contact bearing.

4.2 Bearing Space Ring

The addition of these steel rings, as shown in the assembly drawing in Appendix C, will not affect qualification. Both rings are held in place during the locking of the bearing and cannot move during the running and starting of the motor.

4.3 Larger Double Labyrinth Sealing Slinger and the Enlargement of the Opening Where the Shaft Passes Through the Lower Endshield

The new slinger is made of brass, which is the same material used in the slinger used in the original test motor.

The new slinger is made larger in diameter (5 in. diameter compared to 4.625 in.), has one added axial labyrinth surface (.5 total axial labyrinth length compared to .25 in.), has tighter clearance at the axial labyrinth surface (.032 in. compared to .0925 in. mean diametrical clearance), longer shaft fit (.515 compared to .320 mean length), and less runout between shaft hole and axial labyrinth fits (.005 in. TIR). The overall length of the sealing surface was increased by at least .4 in. The longer shaft fits prevent cocking of the slinger, thus preventing rubbing. See the assembly drawing in Appendix C for details on the above assembly.

The new slinger, with the above changes, will minimize the effect of the larger radial clearance(.0055 additional radial mean clearance) where the shaft passes through the endshield. The above assembly limits the amount of contaminants that can enter the lower end of the motor during the five pressure excursions during the qualification test. The length of the path as compared to the size of the path, plus centrifugal force from the running of the motor, limits the amount of contaminants that can enter the motor during the pressure excursion. Based on the original tests, it was concluded that the only time contaninants can enter the motor is during the five pressure excursions and that the amount was minimal and had no effect on the motor winding or the bearing operation. See the test conclusions in Appendix B. The new slinger should offset the larger shaft clearance, thus no additional contaminants should enter the motor during the five pressure excursions and affect the operation of the motor. Even if additional contaminants did enter the motor, their passage through the bearing would be more restricted because of the large cage construction of the 9218 bearing which acts like a shield as compared to the double row bearing used on the FIRL test motor. If they pass through the bearing, they would then have to pass through the explosion proof shaft seal, which is two inches long and is located between the bearing cap and the shaft, plus the inboard labyrinth sealing slinger at the bearing cap. If it did pass through all the seals, it would still only collect in the endshield and not affect the winding which is four inches above the endshield and separated by an air deflector. Based on the above data, it is concluded that the above changes will not affect the qualification of the motor. See Appendix C for motor assembly drawing.

4.4 Moisture Detector/Heater Lead Seal

The seal material was changed to a new epoxy because the epoxy used in the original seals is no longer available on the market. The new epoxy, which is Epoxylite 2603, has been aged 240 hours at 200° C. (11,000 hours at 140° C. or 22,000 hours at 130° C.), irradiated to 2 X 10^8 rads, vibrated, seismically tested, environmentally tested at 350° F./80° PSIG, and post-environmentally tested for 100 days in steam. The seal was not affected by the above test and the motors were qualified. The motors are used for hydrogen rejection fans for the Washington Public Power Service Nuclear Plants. The tests are the property of the fan manufacturer which is Buffalo Forge.

The change in sealing materials would not affect the motor qualification because all the tests run on the hydrogen rejection fans were more severe than the VEPCO requirements.

4.5 Bearing Thermocouple

The bearing thermocouple is a device which will not be required to operate during the accident and, if it fails during the motor life, it can be replaced without affecting the motor performance or motor operation. Similar designs have been used on motors which have been subjected to seismic levels as high as 9 g's, without affecting the motor operation. The 1250 hp motor, discussed in 4.1, had bearing temperature thermocouples at the top bearing which saw accelerations as high as 9 G's.

5. SUMMARY

Based on the data shown in this Addendum, it is concluded that the changes made in Model 5K6319XJ1B to Model 5K6319XJ1D will not affect the qualification of the inside containment recirculation spray pump motors for the Surry and North Anna Stations for Virgina Electric Power Company, as covered by Dockets 50-280 and 50-281.

Also, it is concluded that the changes made will prevent further lower bearing problems with the above motors.

MWS/djh/Engrg-10

APPENDIX A

BEARING & GREASE MFG. REPORT ON MATERIAL FROM FIRL TEST MOTOR

1. LETTER FROM TEXACO ON REGAL AFB3 GREASE
2. LETTER FROM NEW DEPRTURE ON LOWER 5218 DOUBLE ROW BEARING
3. LETTER FROM SKF ON UPPER 63162Z BALL BEARING

MAIL-O-GRAM

Port Arthur, Texas, March 15, 1973

GENERAL ELECTRIC CO.
SAN JOSE, CALIFORNIA
USED REGAL AFB 2 GREASE SAMPLES

3/17

Mr. R. J. Ronan
Los Angeles, California

Your February 21 subject memorandum requested that we examine some used Regal AFB 2 Grease samples apparently subjected to pure gamma radiation in an electric motor performance test.*

The grease samples were enclosed in folded metal foil. The only identification given was that shown under sample identification on Table I, attached. Only a small amount of each sample was available which limited our examination to emission spectrographic, infrared and X-ray diffraction examination. Pertinent information is given in Table I, attached.

The samples were brown due to iron oxide contamination. The textures of the first three greases showed varying degrees of lumpiness and were of soft consistency. The fourth sample appeared to approximate normal texture and consistency. Aside from the lumpiness the grease would be expected to provide lubrication.

The first three grease samples listed contained high percentages of ash 19.4-35.0 wt%. The fourth sample had an ash content of 1.31 wt% compared with a typical value of 0.33 wt% for Regal AFB 2. Basis emission spectrographs the contaminants represented by the ash were predominantly iron-containing materials.. In sample 421-FS-73 X-ray diffraction analysis showed the presence of Fe_3O_4 and αFe_2O_3.. The unidentified material was too complex and resulted in undefinable patterns.

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* We were unable to locate in our reference material details of the test - IEEE Guide for Class I Motors Installed Inside the Containment of Nuclear Power Stations.

TEXACO

PETROLEUM PRODUCTS

RESEARCH & TECHNICAL
DEPARTMENT
TECHNICAL SERVICES DIVISION

TEXACO INC.
3350 WILSHIRE BOULEVARD
LOS ANGELES, CALIF. 90010

March 19, 1973

General Electric Company
2155 South First Street
San Jose, California 95150

Attention Mr. M. W. Sheets

Dear Sirs:

In your letter of February 12, 1973, you requested examination of four small samples of used Regal AFB2 which had been exposed to radiation in an electric motor at Franklin Institute laboratories.

The attached copy of Mr. W. T. Shepherd's letter of March 15, 1973 to me gives results of laboratory testing. The greases appeared to be in a condition which would afford satisfactory lubrication, but the presence of iron oxide indicates that corrosion or wear has occurred in the bearing surfaces. The extent of such corrosion and/or wear can only be determined by an examination of the various motor components. It is noted that calcium was present in small amounts in three of the four samples. Calcium is not present in Regal AFB2, and its presence suggests that some calcium soap grease may have been used at some time in these motor bearings.

Sincerely yours,

R. J. Ronan

R. J. RONAN

RJR:ME
Attachment

The presence of excessive amounts of iron oxide in the greases from the top and bottom of the top bearing and the top of the bottom bearing indicate that these bearings experienced appreciable wear and/or corrosion. The bottom bearing sample contained appreciably less iron oxide.

Infrared analyses did not show a close relationship to unused Regal AFB-2, but at same time there was no evidence that the greases had undergone substantial deterioration. Electron micrographs showed the presence of lithium soaps in all four samples. Heating the greases for the ash test indicated presence of some water by "crackling," but the amount present was judged to be minimal.

In summary, the performance of Regal AFB 2 under the IEEE test conditions is not clear from the condition and analyses of the samples. We assume the purpose of the IEEE test is to predict what performance can be expected in actual service. In this regard GE should establish the source of iron oxide and how it may relate to lubrication and/or corrosion. Prior studies under static conditions have indicated that Regal AFB 2 will experience degradation by radiation levels of 3.0 x 10^8 roentgens in a partial vacuum and by 1.2 x 10^8 roentgens in air*. Regal AFB 2 after dosages of 1.2 x 10^8 roentgens was subjected to the High Temperature Performance Test, 10,000 rpm (F.T.M.ST.No. 791B Method 333.1). Hours to failure at 250°F were 3048, 880, 3036**.

W. T. Shepherd

W. T. SHEPHERD

MRH-MJC
Attachment
EABk

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* Research Report 402-205 page 12, values reported as 2.5 x 10^8 rads, 1.0 x 10^8 rads, respectively.

** Memo, A. Sellingsloh - O. P. Puryear 6-11-62, subject: "N.S. Savannah Lubricants Regal Starfak Premium 2."

TABLE I

Used Regal AFB 2 Greases*
General Electric Company

Sample Number PARL- -FS-73	419	420	421	422
Sample Identification (Source)	Top of Top Bearing (Shielded Bearing)	Bottom of Top Bearing (Shielded Bearing)	Top of Bottom Bearing	Bottom of Bottom Bearing
Odor	Burnt	Burnt	Burnt	Burnt
Color	Brown	Brown	Brown	Brown
Texture	Soft with some lumps	Soft & lumpy	Intermediate texture, lumpy	Mealy but not lumpy, essentially normal
Estimated Sample Size, grams	3	3	1	0.5
Test Results				
Ash, Wt.%	19.4	21.4	35.0	1.31
Emission Spectrographic Analysis of Ash				
Major Component 10-100% of Ash	Iron	Iron	Iron	Iron
Minor Components 1-10% of Ash	-	Lithium	-	Lithium
Components in Small Amounts 0.1-1% of Ash	Calcium Lithium Manganese	Calcium Manganese	Calcium Manganese	-

* From motor tested per IEEE 334 Guide for Class I Motors Installed Inside the Containment of Nuclear Power Stations.

TABLE I (CONT'D)

Sample Number PARL- -FS-73	419	420	421	422
X-ray Diffraction Analysis				
Hexane Insolubles	Major Unidentified + Lithium Soap	Unidentified	Fe_3O_4 & αFe_2O_3	Lithium Soap
Hexane Insolubles Ash	αFe_2O_3 + Unidentified	-	αFe_2O_3	
Electron Micrographs				
Lithium Soap Fibers	Present	Present	Present	Present

NDH NEW DEPARTURE · HYATT BEARINGS
DIVISION OF GENERAL MOTORS CORPORATION

2704 SOUTH GRAND AVENUE
SANTA ANA, CALIFORNIA 92705
TEL. (714) 540-2402

March 20, 1973

General Electric Company
Large AC Motor & Generator Dept.
P.O. Box 6376
San Jose, Ca. 95150

Attention: Mr. M.W. Sheets, Project Engineer

Gentlemen:

Enclosed is our engineering laboratory's report #E-17034 covering their analysis of the NDH #5218WL1270A bearing, G.E. part number 629A218DR, which the writer picked up at the time of his visit with you on February 21.

As the report indicates, as received the bearing contained considerable foreign matter. However, it had not failed and, in our opinion, was capable of an indefinite amount of additional service.

We hope the information is useful to you. If you have any questions regarding the report please let us know.

Very truly yours,

NEW DEPARTURE-HYATT BEARINGS

W. C. Willey

W.C. Willey, Sales Engineer

WCW/w

EN-234

NO: E-17034

DATE: 3-15-73

NDH NEW DEPARTURE · HYATT BEARINGS

DIVISION OF GENERAL MOTORS CORPORATION

ENGINEERING SERVICE REPORT

DH SALESMAN: W. C. Willey
ALES OFFICE: Berkeley
ELD REPORT: C/R #289
EFERENCE: (2-21-73)

General Electric Co.
(CUSTOMER)

San Jose, California
(ADDRESS)

BEARING SIZE AND QUANTITY
5218W L1270A (1)

SUBJECT OF INVESTIGATION

During an inspection of a 300 hp vertical shaft motor at a Virginia Electric Power installation, water was found in the lower housing, the housing which locates the 5218W bearing. The bearing is now submitted as removed* from the motor for NDH examination and comments. G.E. would like to know what problems can be anticipated based on the present condition of the bearing.

CONCLUSION

This bearing, as received, contained a "lapping compound" consisting of wear size magnetic particles and a lithium soap grease. The bearing also resisted hand rotation efforts due to thickness of the compound.

However, a thorough cleaning restored the bearing to a useable condition. While no measurable lapping had occurred to the rolling contact surface, continued service (as received) would have resulted in an increase in internal clearance and a loss of lubricity which may be manifested as vibration (noise), ball separator malfunction characteristics, to an inadequate lube failure with heat stressed balls and raceways.

OPIES TO:
C. G. Hayden
W. C. Willey

INVESTIGATED BY	NEA
APPROVED BY	CGH/

SKF INDUSTRIES, INC.
ENGINEERING AND RESEARCH CENTER

ROLLING BEARINGS
MOTION ENGINEERING
BALL AND ROLLER BEARINGS

March 27, 1973

General Electric Company
San Jose, California 95125

Attention: Mr. M. W. Sheets
Project Engineer

Subject: SKF bearing 6316 2Z
In 300 HP G.E. Vertical Totally Enclosed
Motor For Nuclear Power Stations
SKF Reference RG 939225

Gentlemen:

This confirms our telephone report on the condition of this bearing removed from the motor in the Franklin Institute test and that you sent to us for evaluation.

By definition to a bearing manufacturer, a bearing failure means that stage in a bearing's life where fatigue spalling occurs. By that standard, the bearing did not fail. No one can predict the life in an used bearing, so the life remaining is unknown.

The details of our observations follow. The shield on the marked side spins freely and the other is slightly loose. The internal radial looseness is now 100 micrometers (.004") greater than the maximum of a normal internal clearance range. (For this size of bearing the normal internal clearance is from .0004" to .0012".) Both ball paths are discolored gray and show a wavy pattern. The ball paths exhibit the condition known as frosting. Both rings are now highly magnetic. The O.D. of the

ELEVEN HUNDRED FIRST AVENUE, KING OF PRUSSIA, PENNSYLVANIA 19406 • TELEPHONE: 215-265-1900

outer ring exhibits fretting corrosion from minute movement between it and the housing bore. In the event you would like to have this bearing for further discussion, we will hold it for three weeks before scrapping it.

Truly yours

SKF INDUSTRIES, INC.

W. H. Keire
Chief Service Engineer

WHK:saf

APPENDIX B

SUMMARY OF QUALIFIED TOPICAL REPORT BASED ON TEST AT FIRL
(SECOND ADDENDUM DATED 6/12/73)

III. CONCLUSION

Below are the conclusions to the report.

1. The motor was successfully heat aged to equal 40 years of life and subjected to a gamma radiation dosage of 2×10^8 roentgens as specified by the Stone & Webster specification.

2. The motor was given a seismic test equal to that specified by the specification without any noticeable effect on the motor.

3. The motor was successfully put through a design basis even environmental simulation and found to be still in an operable condition at the end of the test based on the following:

   A. The motor including cables and terminations which are same as used by the Virginia Electric Power Compan in field installations, did not fail or show any indication of unbalance throughout the entire test.

   B. Following the final full load test, the motor successfully passed a high potential test of 2/3 X (twice rated voltage + 1,000 VAC) which is equal to 1280 volt for 1 minute and at all times meggered in excess of the minimum recommended insulation resistance level specified by IEEE Number 43 of 1.46 meg ohms for 460 volt motors. Before the high potential test, the insulation resistance reading was 100 meg ohms. After the test it was 88 meg ohms and after the disassembly at the Philadelphia Service Shop it was up to 220 meg ohms. The above differences are from the effects of moisture in the winding.

C. The final inspection showed that the spray solution did enter the motor during the test. From observations made during the test by disconnecting the pressure tap in the bottom endshield, the solution was found after the first transient but not after the second through fifth transients or during the seven day test. The only time the motor was running during the pressure increase was during the first transient.

From observations made during disassembly, the solution entered through the top bearing and ran down the motor into the lower bearing and endshields. Based on the insulation resistance and high potential tests covered in B, the winding shows little effect from the solution. The bearings which were analyzed by both bearing manufactu following the disassembly had grease saturated with the spray solution, its residue and iron oxide washed from the cast iron parts and corrosion from the above, did not fail and are still operable.

The grease from the motor was sent to the Texaco Oil Company who reported that even with the grease saturated with the same material seen in the bearings, it still had lubrication life left in it.

D. The chamber pressure and temperature were controlled continually by varying the steam input, the temperature of the spray solution and the use of cooling coils. Both chamber pressure and temperature were recorded continually on a two pen recorder. During the five transie and the seven day test, the chamber was saturated by the steam and the 20 gallons per minute spray solution. The only time the pressure differed between the chamber and the inside of the motor was during the rapid pressure rises.

E. The spray solution concentration met the Stone & Webster specification and was circulated at the ends of each transient and during the seven day test.

F. Because the thermocouple terminations in the winding, were exposed to the motor inside ambient air, the temperature was affected by the inside ambient air. This results in the temperature variation seen during the test. It also counts for the lower temperature seen during the seven day test which were below the expected winding temperature. In this case, the thermocouple measured lower than the actual winding temperature because the thermocouples were not tight to the endturns of the winding. Taking the above into consideration, the winding temperatures never exceeded the 180°C (356°F) rating of the Class H insulation used in the motor.

G. The thermocouples in the bearings were installed in the grease passages in the endshields and the thermocouple terminations could come in contact with the endshield surfaces. This could account for the variations and the high temperatures seen in the upper bearing thermocouple because the upper endshield came in direct contact with the steam entering the chamber. Even with the high temperature and the variations seen, the bearings and grease did not fail and are still in an operable condition.

In summary, the data from the test verifies that the tests meet the Stone & Webster specification and that the specific Class 1E totally enclosed fan cooled vertical motor manufactured by the General Electric Company passed the test without failure and had continued life and can be used in the containment of the Surry Nuclear Power Station and is capable of operating under design basis even (DBE) condition.

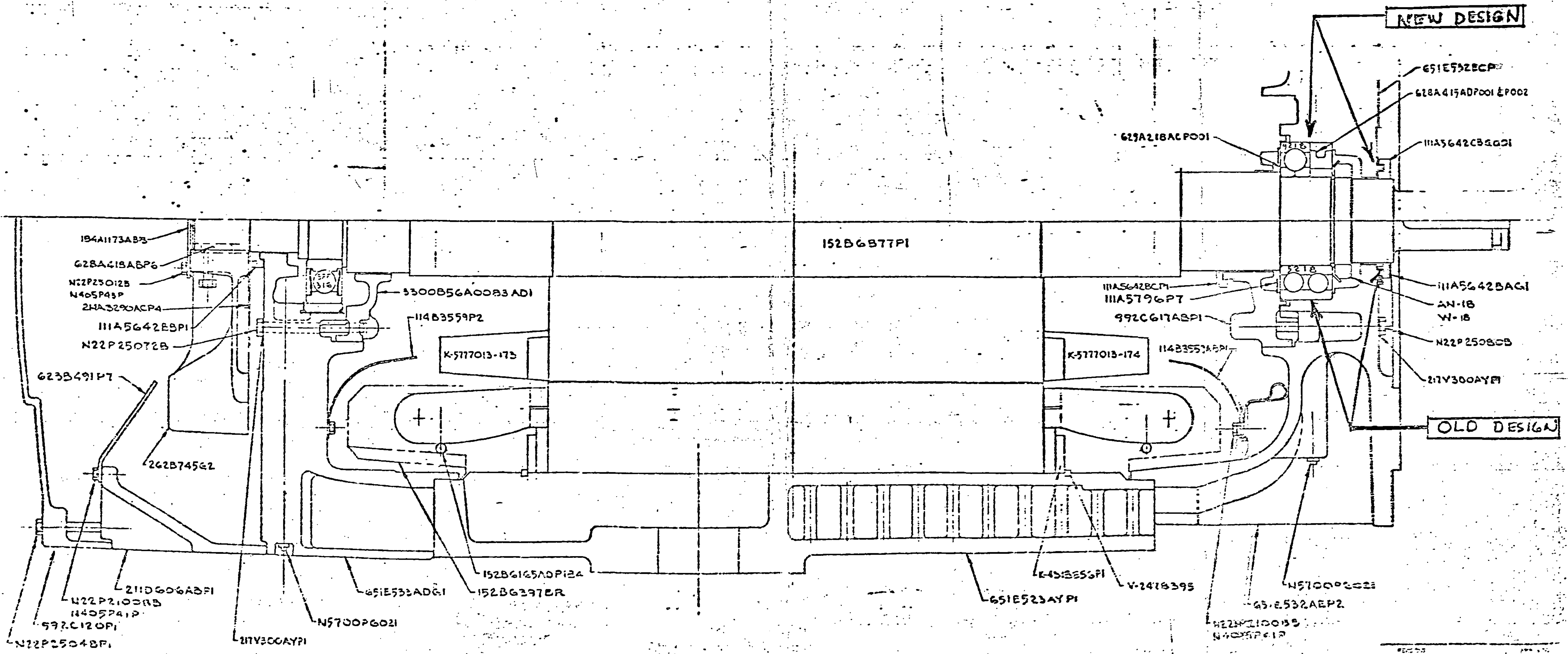
APPENDIX C

MOTOR ASSEMBLY DRAWING WITH NEW AND OLD BEARING CONSTRUCTIONS

GENERAL ELECTRIC 115D7992

115D7992

ASM LAYOUT

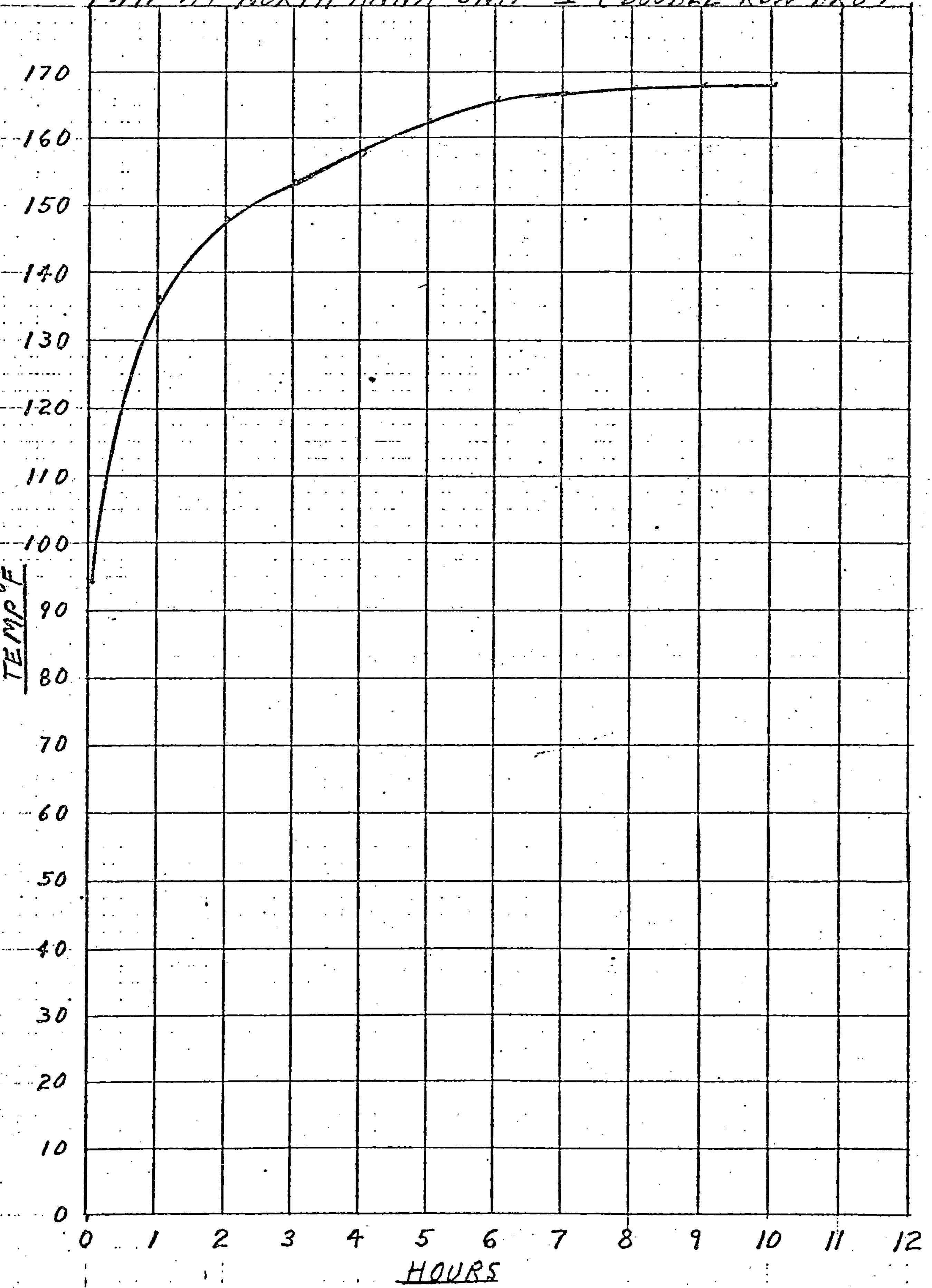


115D7992

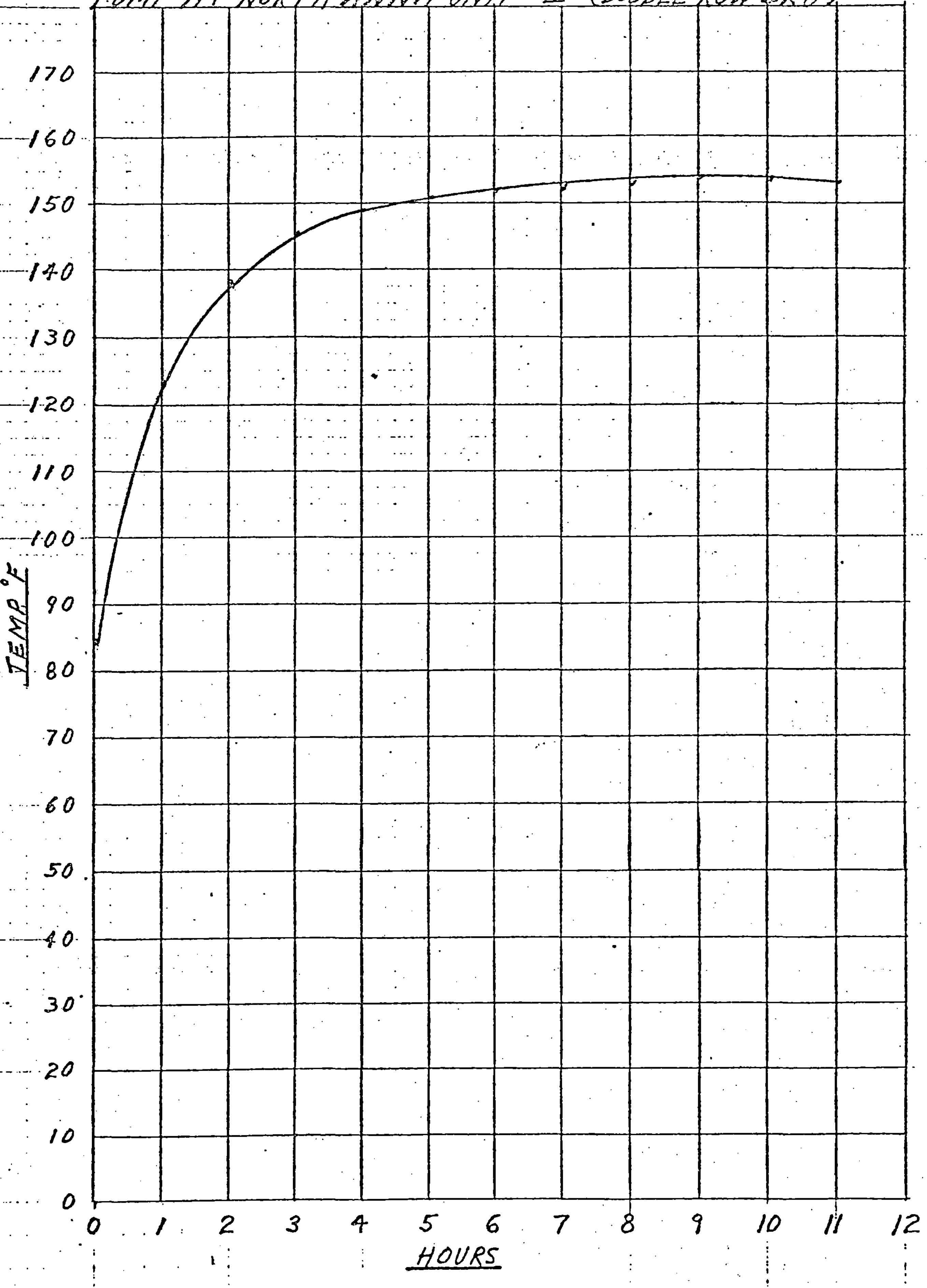
APPENDIX D

TEST DATA OF MOTOR RUN AT NORTH ANNA ON PUMPS WITH OLD BEARING CONSTRUCTION

TEST DATA CURVE OF BEARING OUTER RACE TEMP VS TIME FOR LOWER THRUST BEARING FOR MOTOR MARK NO. 1-RS-P1A MOTOR LOADED WITH PUMP AT NORTH ANNA UNIT #1 (DOUBLE ROW BRG)



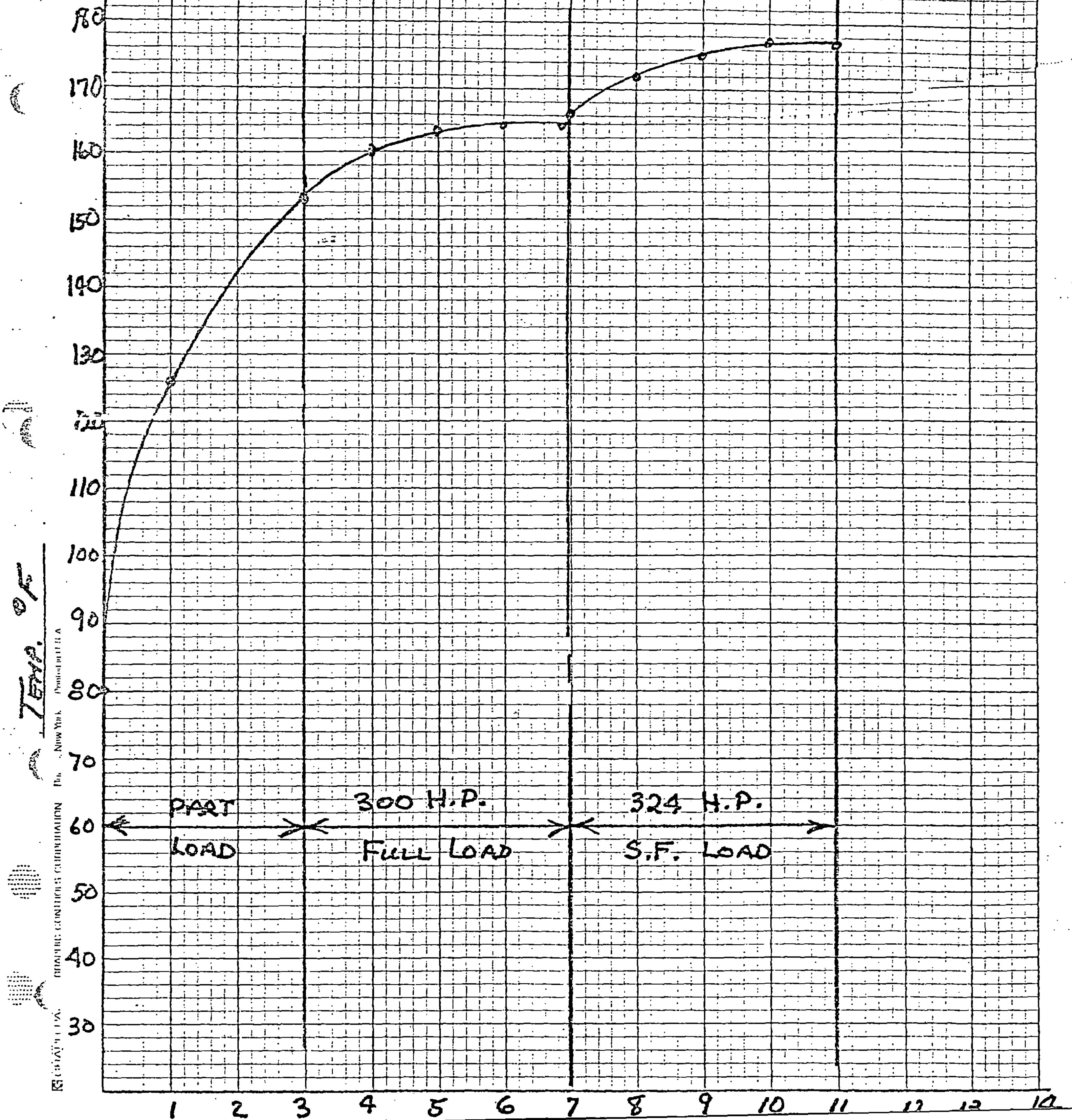
TEST DATA C[illegible]RVE OF BEARING OUTE[illegible] RACE TEMP.
VS TIME FOR LOWER THRUST BEARING FOR
MOTOR MARK NO. 1-RS-P1B MOTOR LOADED WITH
PUMP AT NORTH ANNA UNIT #1 (DOUBLE ROW BRG)



APPENDIX E

TEST DATA OF MOTOR RUN AT SAN JOSE WITH NEW BEARING CONSTRUCTION PLUS THRUST LOAD

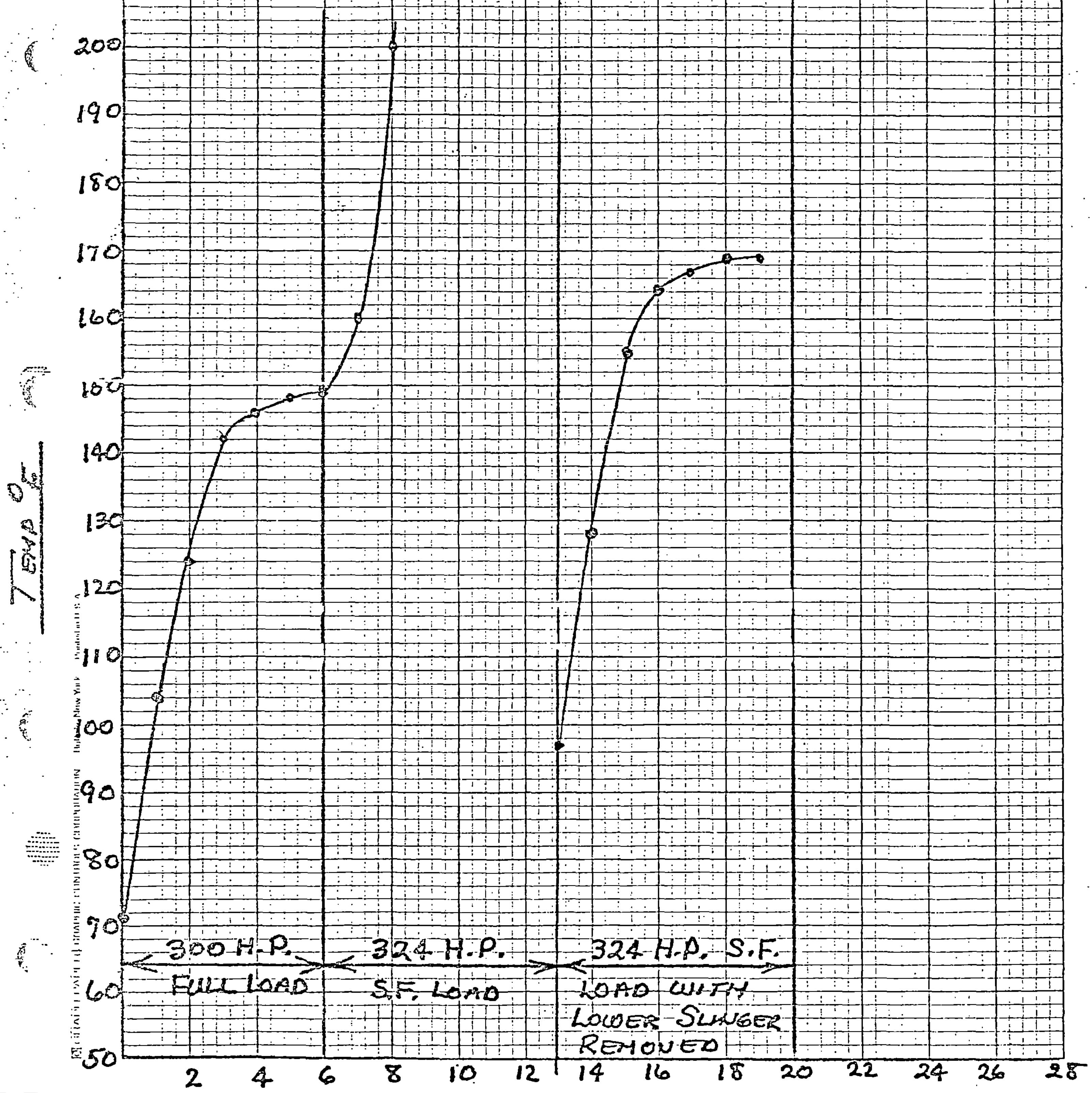
TEST DATA CURVE OF BEARING OUTER RACE TEMP. VS TIME FOR LOWER BEARING FOR MOTOR BUILT UP OF PARTS FROM MOTORS RETURNED TO SAN JOSE AND WITH NEW BEARING CONSTRUCTION PLUS THRUST LOAD. TEST RAN AT G.E. SAN JOSE (MRC9218 BRG.) (SAME MOTOR USED IN APPENDIX F)



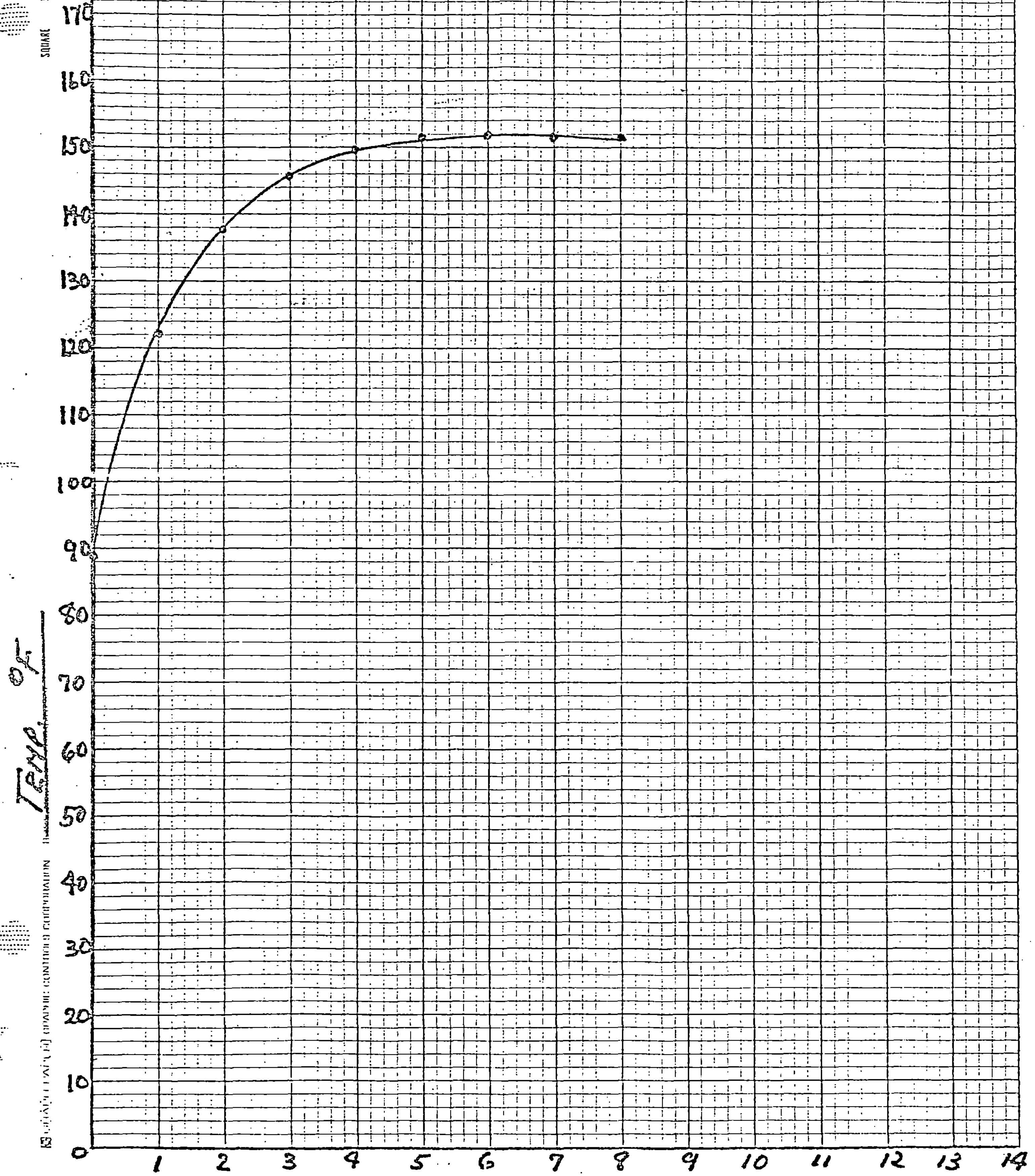
APPENDIX F

TEST DATA OF MOTOR RUN ON PUMP AT BINGHAM WILLAMETTE PUMP CO. WITH NEW BEARING CONSTRUCTION

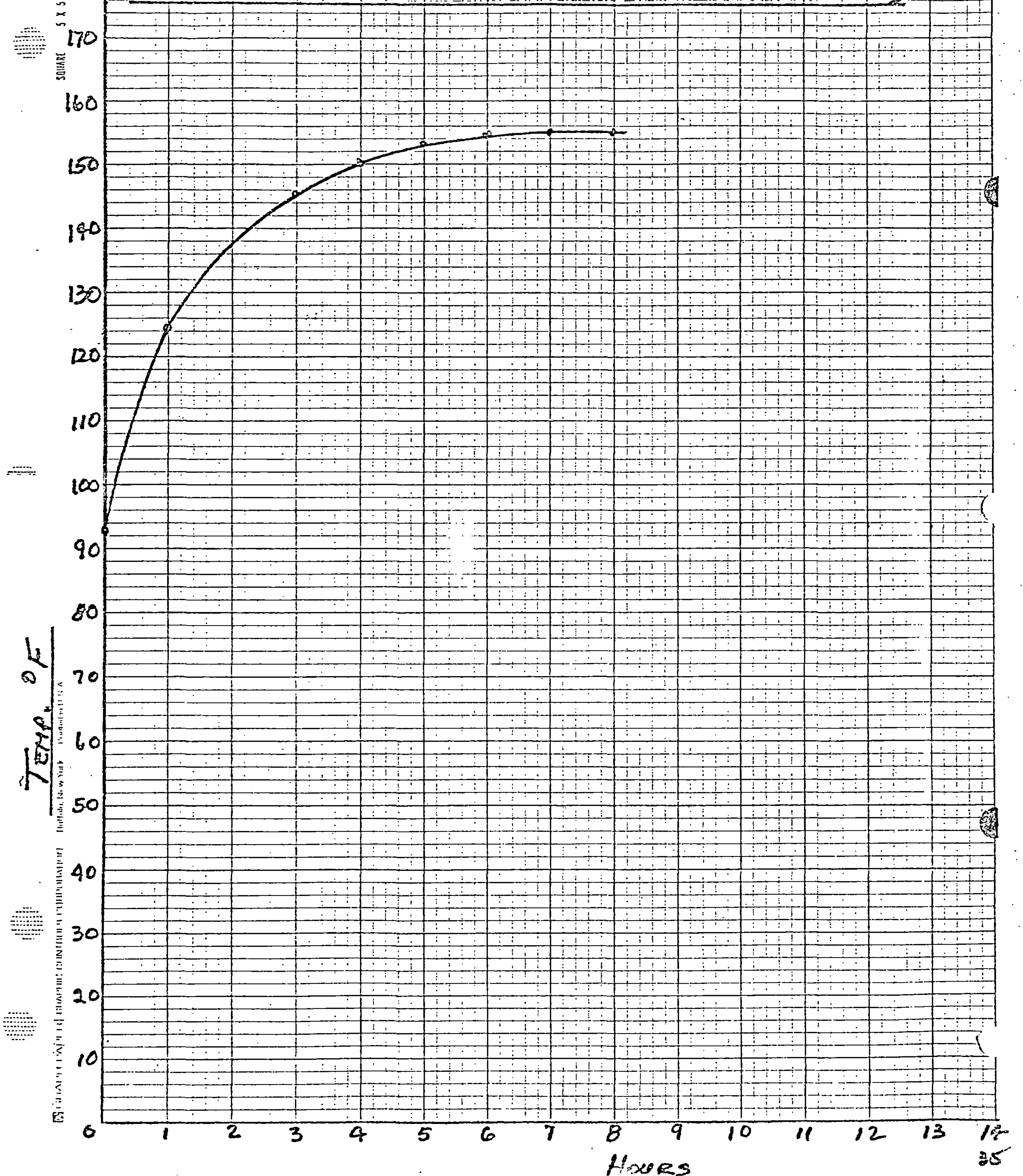
TEST DATA CURVE OF BEARING OUTER RACE SPACER RING TEMP VS TIME FOR LOWER BEARING (RING LOCATED DIRECTLY BELOW BEARING OUTER RACE) FOR MOTOR BUILT UP OF PARTS FROM MOTORS RETURNED TO SAN JOSE AND WITH NEW BEARING CONSTRUCTION PLUS LOADING BY PUMP AT BINGHAM-WILLAMETTE CO. IN PORTLAND OREGON (MRC 9218 BRG) (SAME MOTOR USED IN APPENDIX E)



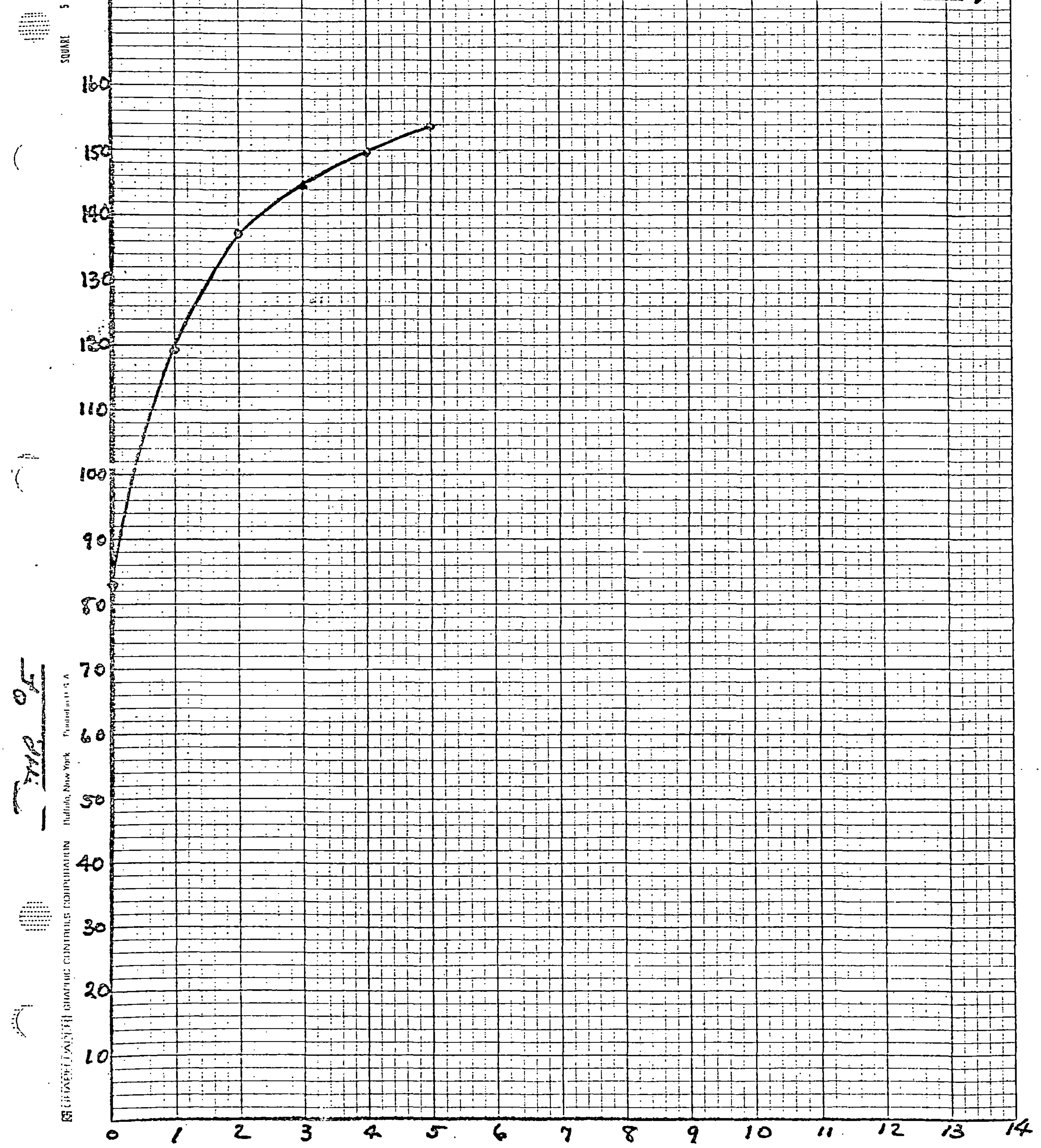
TEST DATA CURVE OF BEARING OUTER RACE TEMP. VS TIME FOR LOWER THRUST BEARING FOR MOTOR S/N ENJ 531021 WITH MOTOR LOADED WITH PUMP AT NORTH ANNA (MRC 9218 BRG.)



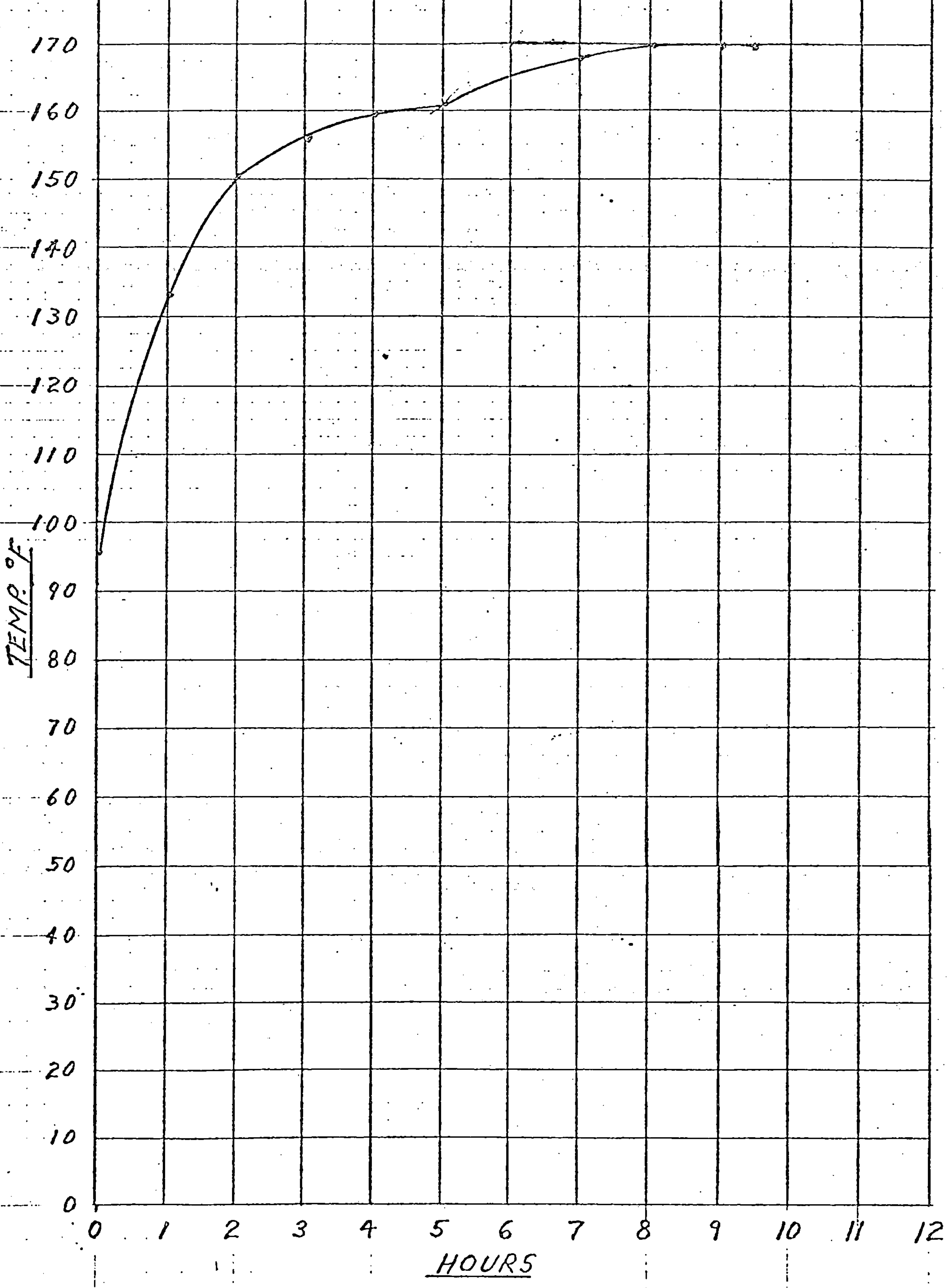
TEST DATA CURVE OF BEARING OUTER RACE TEMP. VS. TIME FOR LOWER BEARING FOR MOTOR S/N EHJ524018 WITH MOTOR LOADED WITH PUMP AT NORTH ANNA (MRC 9218 BRG.)



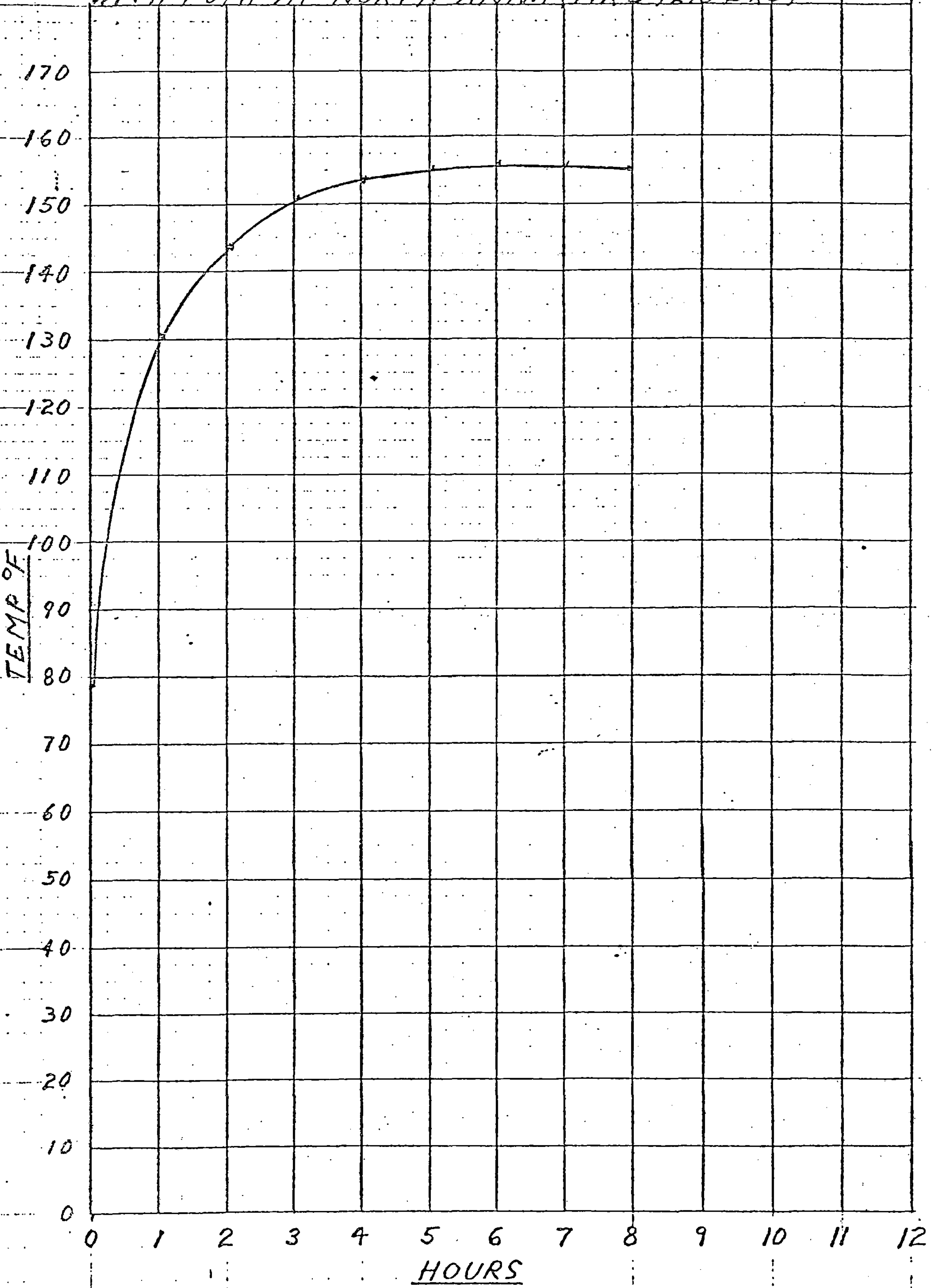
TEST DATA CURVE OF BEARING OUTER RACE TEMP. VS TIME FOR LOWER THRUST BEARING FOR MOTOR S/N EHJ524019 WITH MOTOR LOADED WITH PUMP AT NORTH ANNA (MRC 9218 BRG.)



TEST DATA CURVE OF BEARING OUTER RACE TEMP.
VS. TIME FOR LOWER THRUST BEARING FOR
MOTOR S/N JJJ 919019 WITH MOTOR LOADED
WITH PUMP AT NORTH ANNA (MRC 9218 BRG)



TEST DATA [illegible]RVE OF BEARING OU[illegible]R RACE TEMP. VS TIME FOR LOWER THRUST BEARING FOR MOTOR S/N LHJ112 9013 WITH MOTOR LOADED WITH PUMP AT NORTH ANNA (MRC 9218 BRG)



APPENDIX H

SUMMARY OF EIGHT MOTORS FOR SURRY & NORTH ANNA STATIONS

MOTOR S/N	MODEL NO.	BEARING CONST		PUMP TEST		REBUILD LOCATION	
		NEW	OLD	N.A. No1	N.A. No. 2	SANJOSE	RICHMOND
JJJ 919019	5K6319XJ1D	X			X	X	
JJJ 919018	5K6319XJ1D	X			X		X
EHJ 531021	5K6319 XJ 1D	X			X		X
EHJ 524018	5K6319 XJ 1D	X			X		X
EHJ 524019	5K6319XJ 1D	X			X		X
LHJ 1129013	5K6319 XJ 1D	X			X		X
JJJ 926011	5K6319 XJ 1B		X	X			
JJJ 926012	5K6319 XJ 1B		X	X			

APPENDIX I

LETTER FROM MRC ON 9200 SERIES BEARING COMPARED TO THE 7200 SERIES BEARING

TRW
MARLIN-ROCKWELL DIVISION

RECEIVED
JUL 2 1979
ENGINEERING
San Jose Motor Plant

June 27, 1979

General Electric Company
San Jose Motor Plant
2155 South First St.   M/C 965
San Jose, CA 95112

Attention: Mr. M. W. Sheets
Project Engineer

Reference: Ball Bearing MRC9218U (Alternate MRC9218UDT)

Gentlemen:

There is no question about the capability of this bearing to withstand a seismic effect radial shock load of 0.5G.

It is our understanding that you have documented the capability of a similar size 7000 series angular contact thrust bearing to withstand 9.0G shock load. A 9000U series bearing of the same size has identical internal characteristics of ball complement, race curvatures, and contact angle. These bearings are designed to be capable of being duplexed (e.g. 9218UDT) for mounting with a 7000 series bearing in tandem, and equally sharing the thrust load in one direction.

The actual radial internal clearance of the 9000U series bearing is less than for the corresponding 7000 series bearing, because of the "gothic arch" configuration of the split inner ring race. Under radial load the balls contact both halves of the two piece inner ring, instead of the extreme bottom of a race having a complete uninterrupted radius.

If you have further questions, please do not hesitate to contact us.

Very truly yours,

Don Williams

Don Williams
Account Manager,
Western Zone

DW/ar
cc: RLD

840 HINCKLEY ROAD BURLINGAME, CALIFORNIA 94010 PHONE 415-697-9154
Progressive Leadership in Precision Bearings

MRC bearings