AEOD ENGINEERING EVALUATION REPORT*

UNIT: E.I. Hatch Units 1 and 2
DOCKET: 50-321; 50-366
LICENSEE: Georgia Power Company
NSSS/AE: General Electric/SCSI & Bechtel

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SUBJECT: HIGH PRESSURE COOLANT INJECTION SYSTEM PERFORMANCE AT E.I. HATCH UNITS 1 and 2

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SUMMARY

A study was conducted of the performance of the high pressure coolant injection (HPCI) system at E.I. Hatch Units 1 and 2. It was found that while problems have continually been experienced in the HPCI systems of both Hatch units, these faults were consistent and comparable to those experienced in all domestic boiling water reactors (BWRs) having a HPCI system. The principal faults were found to be in the areas of pressure instrumentation, valves, turbine trip and throttle system components, and human factors. These areas were consistent with other BWR facilities. Likewise, the effects of these faults on the availability of the HPCI system were similar. The pressure instrumentation problems usually had little effect on the system availability but the valve and turbine trip and throttle system faults almost always adversely affected the system availability. Based on these findings, it was concluded that further separate monitoring of the HPCI systems performances at both Hatch units was not necessary.

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*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

1. INTRODUCTION

The high pressure coolant injection (HPCI) system is one of the principal engineered safety features incorporated into the majority of the currently operating domestic boiling water reactors (BWRs) produced by General Electric. As such, it is essential that this system have high availability and reliability. Past operating experience, however, has shown that the originally predicted performance goals were not being attained. Consequently much work has been done by both individual licensees and industry groups to improve the HPCI system operational performance. One report which illustrates some of this work is NSAC-53 "Reliability of BWR High Pressure Core Cooling" (Ref. 1).

Some of the operating BWRs appear to have had significantly poorer HPCI system performance histories than other operational plants. One of these is Georgia Power Company's E.I. Hatch Units 1 and 2. This report documents a study performed by AEOD of the operational history of the HPCI system at E.I. Hatch. The goals of this AEOD study included: (1) attempt to determine principal HPCI fault areas; (2) see if any significant trend or pattern for these faults was evident; (3) compare the findings with those of previous industry studies to see how the Hatch HPCI system performance compared with the rest of the domestic BWR plants containing HPCI systems; and, if evident, (4) make appropriate suggestions for ways to improve the HPCI performance at Hatch. The basic plant data for this study was derived from E.I. Hatch licensee event reports. The industry experience data utilized was taken from several industry reports which included generic HPCI operational experience.

2. DISCUSSION

The study of the operational history of the HPCI systems at E.I. Hatch was divided into two main parts: (1) an analysis of the operational event reports submitted to the Nuclear Regulatory Commission by the licensee for E.I. Hatch Units 1 and 2 and (2) an investigation of reports produced by industry organizations which contain generic as well as plant-specific HPCI system operational information. Discussions of these study parts follow.

2.1 Operational Event Report Analysis

To begin this study, a computer-generated listing was obtained of all the abstracts of events involving the HPCI system at E.I. Hatch Units 1 and 2. This listing of event abstracts was developed from the operational event reports contained in the Nuclear Safety Information Center (NSIC) licensee event report data file and the NRC Sequence Coding and Search System. The abstracts were then manually screened to obtain a list of reports which contained only actual HPCI faults. Eliminated were those abstracts which mentioned the HPCI system but did not indicate that a HPCI system fault existed (e.g., actuations without faults of the HPCI system). Additionally, several applicable event reports which had been received by AEOD but which were not yet listed on either the NSIC or SCSS data bases were included. The net result of these efforts was a compilation of HPCI-related fault event reports for Hatch Units 1 and 2 which covered the period from the time each unit was issued an operating license through 1983. A listing of these HPCI fault event reports is given in Table 1. *

The abstracts of the reports in the final compilation were then screened to determine the primary HPCI fault area, the probable fault root cause, and the resulting effect each fault had on the capability of the system to perform its safety function. During this screening, the following conventions were used:

*All tables and figures are included in the Appendix to this report, beginning on page 19.

(1) If similar items were found in a faulted condition at the same time, a single fault count and the system functional effect of all the fault items considered together were recorded. For example, if two pressure switches were found to be in a faulted condition at the same time from the same cause, only a single fault count was recorded and only the system effect of having both switches in a faulted condition at the same time was noted.

(2) If multiple occurrences (i.e., occurrences at different times) of the same fault were documented in a single event report, each occurrence was recorded as a separate fault along with its associated effect on system safety functionality. For example, if a report noted the finding of a valve fault at one time and then at a later date a similar valve fault, two fault counts were recorded along with the system functional effect of each fault.

(3) The functional effect on the system was judged on the basis of whether or not the fault rendered the HPCI system incapable of performing its safety function without corrective actions. For example, if a valve fault was reported but the fault was such that the HPCI system could still perform its safety function without correcting the valve fault, the system was considered to be functionally available.

The resulting data was then analyzed to determine the principal characteristics of the HPCI system faults at E.I. Hatch Units 1 and 2. Some of the more significant characteristics are noted in the following paragraphs.

While the Unit 1 event reports covered about twice the Unit 2 time span, the overall number of event reports indicating HPCI faults was approximately equal (i.e., 75 for Unit 1 and 81 for Unit 2). The yearly distribution of these reports showed several characteristics.

The number of HPCI event reports for Unit 1 rose sharply during the first three years of full operation of Unit 2, averaging two to four times the number of reports issued prior to the start of Unit 2. In 1982, the number of reports for Unit 1 returned to the average number issued prior to Unit 2 operations but in 1983, the number rose again to the levels experienced in the first two years of Unit 2 operation. For Unit 2, the number of HPCI event reports was approximately four times the number issued for Unit 1 during similar four year startup operational periods. The number of event reports decreased markedly at Unit 2 in 1982 but then almost tripled in 1983 from the 1982 level. The 1983 event report level, however, shows a decrease from the previous worst years. Figure 1 illustrates the yearly distribution of these event reports for both units.

Like the number of event reports, the total number of faults recorded in these reports was similar (i.e., 92 for Unit 1 and 89 for Unit 2). The distribution of these faults also corresponded closely to the event report distribution. In general, the faults reported at each unit occurred in the same categories of (1) pressure instrumentation, (2) human factors, (3) valves, and (4) HPCI turbine trip and throttle system. Likewise, these basic fault categories were made up of very similar items. For example, the pressure instrumentation fault category consisted of faults attributable to instruments manufactured by the same companies. On a unit basis, the Unit 1 HPCI event reports were dominated by pressure instrumentation and human factor faults whereas Unit 2 reports were dominated by pressure instrumentation faults, with Unit 2 reporting one-third more pressure instrumentation faults than Unit 1. Additionally, the pressure instrumentation faults were primarily due to problems associated with instruments manufactured by either Barksdale or Barton, with the number of faults for the instruments manufactured by these two companies approximately equal within each unit. For both units, Table 2 lists the fault categories and associated items while the yearly fault distributions are given in Figure 2. Included in the table is a miscellaneous category with associated items which combines the few faults that did not fall into any of the other categories. Additionally, the table contains a listing of the number of reports and the number of faults recorded for each category and invididual item. Note that the total number of reports listed (i.e., 81 for Unit 1 and 87 for Unit 2) exceeds the actual number of reports reviewed (i.e., 75 for Unit 1 and 81 for Unit 2) since some reports contained multiple faults such as a human factor fault and a valve fault.

On a more detailed basis, pressure instrumentation faults in Unit 1 were uniform on a yearly basis except for a noticeable rise in 1981; however no distinctive quarterly pattern existed for these faults. At Unit 2, the yearly pressure instrumentation fault level was fairly constant for 1979 through 1981 with a dramatic decrease in 1982 and 1983. The majority of these faults occurred in the last three quarters of each year. Except for a sharp increase in 1978 and 1979, the human factor category faults were level at Unit 1 with design and procedure faults accounting for most of the faults. The 1978 and 1979 rise in human factor faults was dominated by design faults, primarily in the last quarter of 1978 and the first two quarters of 1979. Unit 2 showed no particular human factor fault area domination or uneven time distribution. The majority of the valve faults in Unit 1 occurred in 1981, with the overall Unit 1 valve faults being attributable to an equal number of electrical problems and mechanical problems. However, the mechanical problems occurred only in 1981, whereas the electrical problems were fairly evenly distributed throughout the study period. At Unit 2, valve faults were most prevalent in 1979, 1980 and 1983, with these faults attributable to almost twice as many electrical problems as mechanical problems. Additionally, the majority of all Unit 2 valve faults occurred in the last three quarters of 1979, 1980 and 1983. Unit 1 experienced three times the number of turbine trip and throttle system faults as Unit 2. The faults at Unit 1 started after the first two full years of unit operation, with the majority occurring in the second and third quarters of 1980 and 1981. The Unit 2 faults occurred in the third quarter of 1979 and the last two quarters of 1983. Miscellaneous faults for both units were dispersed throughout the operational report period of each unit with no one item dominant. Of the six fault items making up the Unit 1 miscellaneous category and the nine items in Unit 2, only problems concerning the auxiliary oil pump at each unit were common to both units. To illustrate these points, Table 2 lists the fault counts at each unit and Figures 3 through 6 show detailed time distributions. More specifically, Figures 3 and 4 illustrate the total yearly fault counts for Units 1 and 2, respectively. Included in these two figures are indications of the contributions to each yearly count by the fault categories. Figures 5 and 6 (for Units 1 and 2, respectively) show the quarterly distribution of the individual fault items which make up each fault category. Highlighted in these two figures are the enveloping fault occurrence time spans for each fault item. Noted within each occurrence span are the number of faults recorded in each calendar quarter for each fault item.

With regard to the effect which each fault category and item had on the capability of the HPCI system to perform its safety function, several characteristics were displayed. Overall, approximately 50 percent of the HPCI system faults reported for either unit resulted in the systems being unavailable, with no particular unavailability fault time-dependent pattern evident in either unit. Of the fault categories, the problems in the pressure instrumentation had a minor effect on the overall functional availability of the HPCI system in either unit. Slightly over half of the human factor faults caused the HPCI system to be unavailable. The valve faults as well as the trip and throttle system faults almost always caused the safety function capability of the HPCI system to be lost. Likewise, the items making up the miscellaneous fault category at each unit normally caused the loss of the functional capability of the HPCI system. On a unit basis, the main contributors to the unavailability of the Unit 1 HPCI system were: (1) faults in pressure instrumentation manufactured by Barton; (2) human faults associated with design and maintenance activities; (3) electrical and mechanical problems in valves; (4) turbine trip and throttle system faults; and (5) all miscellaneous faults. For Unit 2, the primary unavailability contributors were: (1) faults in Barksdale pressure instrumentation; (2) human faults in maintenance and operations activities; (3) electrical and mechanical faults in valves; (4) turbine trip and throttle system faults; and (5) miscellaneous faults associated with pumps such as the auxiliary oil pump. Tables 2 and 3 and Figures 7 through 11 illustrate how the faults affected the HPCI system availability at E.I. Hatch. In particular, Figure 7 compliments Figure 2 and shows the calendar year HPCI system unavailability distribution for both units. Included in this figure for reference is the associated overall fault distribution as shown in Figure 2. Figures 8 and 9 (for Units 1 and 2, respectively) illustrate how each fault category item affected the overall availability of the HPCI system. Also shown are the number of times each item led to the HPCI system being either unavailable, available, or judged by the reviewer to probably be available to perform the system safety function. Figures 10 and 11 (which mimic Figures 5 and 6, respectively) graphically show the calendar quarter distribution of those faults that rendered unavailable the HPCI system in each unit.

While the faults in each unit fell into the same basic categories and consisted of similar items, the probable causes for each fault varied widely between units. These causes and their associated effects on system availability are discussed in the next few paragraphs. Note that Table 3 in the Appendix contains a detailed listing of the probable causes associated with each item in the main fault categories for both units. Also, it gives a listing of the number of times each fault category and each probable cause affected in a specified way the ability of the HPCI system to perform its safety function.

Only in the fault category of instrumentation was a pervasive common probable cause apparent; this being setpoint drift. Setpoint drift accounted for 19 of the 24 pressure instrumentation faults at Unit 1 and 25 of the 36 pressure instrumentation faults at Unit 2. However, none of the 19 faults at Unit 1 and only 2 of the 25 faults at Unit 2 rendered the HPCI systems incapable of performing their safety function. The five remaining pressure instrumentation faults at Unit 1 were due to three different causes, with bellows problems accounting for three of the five faults. Of these five faults, only the three bellows problems resulted in the HPCI system being unavailable. At Unit 2, the remaining 11 pressure instrumentation faults were the result of seven different causes, with none of these pressure instrumentation fault causes being the same as at Unit 1. None of the seven causes accounted for more than two faults and four of the eight causes led to the HPCI system being unavailable. Fouled contacts and component interference each accounted for two unavailable cases while electrical shorts and diaphragm problems each caused the HPCI system to be considered not available a single time.

Except for the case of room temperature instrumentation at Unit 1, neither unit displayed a pervasive probable cause of the human factor faults. At Unit 1, the room temperature instrumentation design problem accounted for 11 of the 30 faults attributed to human factors. This particular design problem also led to 10 of the 19 human factor category fault cases where the HPCI system was unavailable. The remaining 19 Unit 1 human faults resulted from 12 different causes, with valve alignment problems responsible for four unavailability cases. Five other causes led to the five remaining human factor fault cases where the HPCI system was not available at Unit 1.

Human factor faults totaled 13 at Unit 2, with the HPCI system not availabe in seven of these cases. Of these 13 faults, only two were caused by room temperature instrumentation design problems with one of these resulting in the HPCI system being unavailable. The remaining 11 human factor faults at Unit 2 were due to eight different probable causes. Five of these eight causes were responsible for the remaining six cases where the HPCI system was not available. Additionally, only two of the eight causes were the same as the Unit 1 human factor fault causes and the resulting system effects were similar; i.e., they had little functional effect.

As in the pressure instrumentation and human factor categories, the probable causes for the valve faults were diverse and not common to both units. This was also true for the turbine trip and throttle system faults and the miscellaneous faults.

Five electrical related and five mechanical related causes led to the 14 valve faults at Unit 1. The 23 valve faults at Unit 2 were the result of eight electrical causes, five mechanical causes and one unknown cause. The most prominent of these causes were three diaphragm caused mechanical faults at Unit 1 and four environment caused faults at Unit 2. Regardless of the cause, however, the effect on the HPCI system was usually negative in that 9 out of 14 and 18 out of 23 times the respective Unit 1 and Unit 2 HPCI systems were rendered unavailable.

Seven causes resulted in the 11 Unit 1 turbine trip and throttle system faults. Five of the causes resulted in eight faults which rendered the HPCI system incapable of performing its safety function. Only three faults were recorded in the Unit 2 trip and throttle system. Attributable to two causes, these three faults all led to the unavailability of the Unit 2 HPCI system.

Finally, six known and three unknown miscellaneous causes resulted in faults which rendered the Unit 1 HPCI system unavailable 10 out of 13 times. Eight known and two unknown miscellaneous causes yielded faults which resulted in the HPCI system at Unit 2 being unavailable 5 out of 14 times.

Based on all of these observations, the following summary of the worst operation performance years can be compiled for each unit:

E.I. Hatch Unit 1 -

1. HPCI events at Unit 1 occurred most frequently in 1979, 1980, 1981 and 1983, with the period between 1979 and 1981 corresponding to the initial start-up period for Unit 2.

2. 1979 was dominated by problems in the design of the HPCI isolation system instrumentation which was based on room versus outside air temperature comparisons. These faults always led to HPCI system unavailability. This problem was corrected, however, and has not recurred.

3. 1980 showed a decrease in faults from 1979 but still greater than prior years. The principal fault causes were turbine trip and throttle system problems and indeterminate problems. Three-fourths of these faults led to HPCI system unavailability. The individual causes of the faults, however, have not recurred.

4. 1981 was the worst year for HPCI problems. The faults reported were almost double the next worse year 1979 and more than double the 1980 level. The principal contributors to this high fault level were mechanical problems in valves and setpoint drift and bellows problems in pressure instrumentation. Additionally, although from different causes, the turbine trip and throttle system continued to have faults at the same rate as in 1980. The pressure instrumentation faults had little effect on the HPCI system availability. The valve faults, which were due mainly to diaphragm faults, and the turbine trip and throttle system faults usually adversely affected the HPCI system availability. Except for continuing setpoint drift problems in the pressure instrumentation, these faults have not continued.

5. 1983 experienced double the faults from 1982, one of the lowest fault years. This fault level was, however, one-half that of the worst year 1981 and was, on average, the same level as experienced in 1979 and 1980. Human factor faults because of maintenance and indeterminate problems and pressure instrumentation faults due to setpoint drift problems were the prime fault contributors. The human factor faults always led to the unavailability of the HPCI system while the pressure instrumentation faults never led to HPCI system unavailability.

E.I. Hatch Unit 2 -

1. Unit 2 events involving the HPCI system have been occurring since unit startup at yearly rates which are comparable to the highest yearly rates at Unit 1. Only in 1982 did a significant decrease in event frequency occur.

2. 1979 was dominated by pressure instrumentation and valve faults with human factor problems also a large factor. Whereas setpoint drift was the principal cause of the pressure instrumentation faults, no repetitive cause was found for the valve and human factor faults. The valve and human factor faults rendered the HPCI system unavailable but the pressure instrumentation faults normally did not.

3. 1980 showed an increased number of valve faults while pressure instrumentation faults remained constant and human factor faults decreased. Appearing for the first and only time were several miscellaneous faults. Room environmental problems were the primary cause of the valve faults which, in turn, led to the HPCI system being unavailable. Setpoint drift problems with the pressure instrumentation continued but these faults did not result in the HPCI system being unavailable. Approximately one-half of the miscellaneous faults adversely affected the HPCI system availablity.

4. 1981 saw a sharp reduction in valve faults but an increase in pressure instrumentation faults. The only other major factor was the appearance of several problems with equipment supports. Neither the support faults

nor the pressure instrumentation faults led to the HPCI system being unavailable. As a consequence, the unavailable status of the HPCI system decreased by almost half between 1980 and 1981. This level was also below the equivalent Unit 1 level for the first time.

5. 1982 faults decreased dramatically from those in the 1979 through 1981 time span. Only problems with pressure instrumentation faults continued but at a much reduced rate. The availability of the HPCI system was, as a consequence, the best of all the years considered.

6. 1983 saw a rebound in the fault rate to a level slightly lower than 1981 and three times the rate of 1982. Setpoint drift problems in pressure instrumentation continued and combined with level instrumentation setpoint drift problems accounted for six of the 16 faults. The other major contributor to this fault rise was the return of valve faults, accounting for five of the 16 faults, and turbine trip and throttle faults, accounting for two of the 16 faults. No single cause led to more than one of these faults. Three of the valve faults and both turbine trip and throttle faults led to the system being unavailable. However, none of the other 11 faults led to the HPCI system being unavailable. This resulted in the second best availability of the Unit 2 HPCI system for the years considered and exceeded the availability of Unit 1 even though the fault rate at Unit 2 was greater than that at Unit 1 for the comparable period.

2.2 Related Studies of HPCI Systems

Several previous studies of the performance of HPCI systems at various facilities have been conducted by different organizations. Three of these studies which are most relevant to a study of the HPCI system at Hatch are summarized in the following paragraphs.

2.2.1 Outages of Emergency Core Coolings Systems-TMI Action Plan Item II.K.3.17

Item II.K.3.17 of the TMI Action Plan (Reference 2) required all domestic licensees to submit a report which detailed outage dates and lengths of outages for all emergency core cooling (ECC) systems. In response to this request, Georgia Power Company produced and submitted a detailed ECC system outage report for both units at E.I. Hatch (Reference 3). Including data on the HPCI system, the report covered the facility operational periods between December 1, 1975 and December 1, 1980 for Unit 1 and July 1, 1978 and December 1, 1980 for Unit 2. For Unit 1, the report listed 29 outages of the HPCI system. Thirteen basic causes were given for these outages with seven valve-related problems and five environmental-related problems the leading cause factors. Six outages were listed for the Unit 2 HPCI system. These six outages were attributed to four basic causes, led by three maintenance-related problems.

Under a technical assistance contract from the NRC, the Franklin Research Center (FRC) reviewed the Hatch submittal and issued a report documenting their findings (Reference 4). FRC concluded that the historic unavailability of the HPCI system in Unit 1 was consistent with the performance of the HPCI systems throughout the industry and was consistent with existing technical specifications. The unavailablity for the Unit 2 HPCI system was found to exceed the industry mean by greater than one standard deviation. This poor performance was attributed primarily to operator problems on motor-operated valves and system instrumentation problems. For illustrative purposes, nine motor-operated valve faults in the Unit 2 HPCI system were cited. The FRC report concluded, however, that NRC-approved programs dealing with these problems had been developed by the licensee. Consequently, the FRC report concluded that these problems should adequately address the above average Unit 2 unavailability of the HPCI system and no further recommendations for improved system or component availabilty were warranted.

As a result of the FRC report, the NRC concluded that the requirements of NUREG-0737, Item II.K.3.17 were met for the Hatch units. In addition, no changes to the technical specifications which would require cumulative outage time limits on any ECC system, including HPCI, were warranted. (See Reference 5.)

2.2.2 Reliability of BWR High Pressure Core Cooling

In 1982 a generic study was published by the Nuclear Safety Analysis Center (NSAC) concerning the reliability of high pressure core cooling systems at domestic BWR facilities (Reference 1). This study was based on licensee event reports issued between January 1978 and May 1981. For this time period, a total of 247 reports were found which described HPCI system problems. Eliminating those reports which noted problems such as instrument drift which did not render the HPCI system incapable of performing its intended function resulted in a population of 117 reports which were submitted by 18 plants. Analyzing these 117 reports, NSAC determined that the principal contributors to HPCI system unavailability were problems with motor-operated valves and faults in the turbine trip and throttle system. The causes identified for these problems varied widely with the most prominent being component failures of such items as torque switches, ramp generators and power supplies. Because of the type of problems and causes found, this NSAC study concluded that the majority of the occurrences might be prevented if improved maintenance and housekeeping programs were developed and implemented by the licensees.

2.2.3 High Pressure Core Cooling System Malfunctions

In April 1981 the Institute of Nuclear Power Operations (INPO) and NSAC jointly issued a report on high pressure core cooling system malfunctions (Reference 6). The report primarily documented a study of an event at Hatch 1 that occurred in 1980 involving the simultaneous loss of the HPCI and the reactor core isolation cooling (RCIC) systems. This report also contained an appendix on the reliability of the HPCI and RCIC systems at all of the then operating domestic BWRs. The reliability discussion focused on summarizing the results of several comprehensive investigations of HPCI operating experience. These investigations were conducted by several organizations including General Electric, INPO/NSAC and Georgia Power. Summaries of the pertinent studies follow.

2.2.3.1 General Electric HPCI/RCIC Upgrade Program

After the 1980 Hatch event, General Electric initiated a review of the licensee event reports (LERs) from 17 operating BWRs written during the years 1977, 1978 and 1979. This study determined that the major contributor to HPCI problems was instrument drift. Instrumentation malfunctions other than drift followed by turbine-related problems and then valve-related problems were found to be the principal sources for rendering the system incapable of automatic actuation. The General Electric study concluded that better system reliability could be attained by a combination of system and hardware improvements and more comprehensive and stronger maintenance, calibration, surveillance and testing programs.

2.2.3.2 INPO/NSAC SEE-IN Program

An INPO/NSAC SEE-IN program study projected that HPCI system malfunctions for all operating plants would be more frequent in 1980 than in previous years. This determination was based on licensee reports submitted by 25 operating BWR plants during the first nine months of 1980 as compared to reports from prior years. With respect to the HPCI system generically, this INPO/NSAC study noted that 82 out of 995 reports recorded HPCI problems. Of these 82 reports, 20 were due to turbine component and turbine control problems and 14 due to instrumentation faults.

2.2.3.3 Georgia Power Company Program

Following the 1980 Hatch HPCI/RCIC event, a special review program was established by Georgia Power Company. One part of this program was the study of the past performance of the HPCI systems at Hatch Unit 1 and Unit 2. Based on operating logs, LERs, deviation reports and maintenance records covering the period from June 1979 to June 1980, it was found that the HPCI systems at both units experienced a total of 16 malfunctions. Equipment or component problems other than instrumentation accounted for 10 of these problems. Instrument drift or malfunctions accounted for three of the problems, with the remaining three malfunctions attributed to three other items. A further look at the deviation reports for the 18 month period preceding June 1980 showed that the HPCI system experienced 46 problems. Of these 46, 10 were experienced at Unit 1 and 36 at Unit 2. Overall, the program determined that turbine equipment malfunctions were the most common faults followed by instrumentation and valve faults. It was also determined that the problem levels were fairly constant over the report periods.

3. FINDINGS AND CONCLUSIONS

The operational event report analysis performed in this study confirmed that continuing problems have been experienced in the HPCI systems at E.I. Hatch. Comparing these findings with those of several industry studies, however, indicates that this system performance is comparable with the industry experience. The major fault contributors were found to be in the areas of pressure instrumentation, valves, turbine trip and throttle system components and human factor problems. These faults and their effect on system availability were found to be consistent with the findings of the industry studies. Consequently, while the HPCI systems at Hatch Units 1 and 2 have had a history of problems, it now appears that these faults are not significantly different from the rest of the domestic BWR plants. Therefore, continued separate monitoring of the performance of the HPCI systems at Hatch does not seem to be necessary. Any additional study should be conducted as part of other studies such as a generic monitoring program on the performance of the safety systems at all nuclear power facilities.

REFERENCES

1. Nuclear Safety Analysis Center. "Reliability of BWR High Pressure Core Cooling." NSAC-53, August 1982.

2. U.S. Nuclear Regulatory Commission, "Clarification of TMI Action Plan Requirements," USNRC Report NUREG-0737, November 1980.

3. Letter from W. A. Widner, Georgia Power Company, to Director of Nuclear Reactor Regulation, NRC, Subject: Submittal of NUREG-0737 Item II.K.3.17 Document, dated January 16, 1981.

4. F. W. Vosbury, G. J. Overbeck, and B. W. Ludington, Franklin Research Center, "ECCS Reports (F-47)," FRC Technical Evaluation Report TER-C5506-191/192, February 8, 1983.

5. Letter from J. F. Stolz, NRC, to J. T. Beckman, Jr., Georgia Power Company, Subject: Review of TMI Item II.K.3.17, Report On Outages of ECC Systems, dated August 10, 1983.

6. Institute of Nuclear Power Operations and Nuclear Safety Analysis Center. "High Pressure Core Cooling System Malfunctions at Hatch 1." (no report number), April 1981.

APPENDIX

TABLE 1

E. I. HATCH UNITS 1 & 2
HPCI SYSTEM FAULT EVENT REPORT LISTING

UNIT 1			UNIT 2		
?(12/74)	79-017	81-068	78-031	80-016	81-096
?(3/75)	79-023	81-078	78-056	80-020	81-104
75-002	79-059	81-082	78-062	80-066	81-111
75-058	79-076	81-088	78-064	80-069	81-115
75-061	79-098	81-102	78-078	80-070	81-116
75-078	79-102	81-109	79-028	80-072	81-120
75-080	79-106	81-120	79-045	80-079	81-120*
76-004	80-012	81-127	79-049	80-089	81-121
76-007	80-023	81-131	79-050	80-090	81-132
76-037	80-049	81-138	79-059	80-097	82-043
76-038	80-052	82-012	79-067	80-098	82-058
76-050	80-069	82-030	79-083	80-101	82-072
76-080	80-088	82-072	79-084	80-109	82-087
77-014	80-108	82-074	79-086	80-111	82-112
77-067	80-110	82-088	79-090	80-112	83-015
77-063	80-114	82-112*	79-096	80-114	83-017
77-083	81-001	83-007	79-098	80-137	83-027
77-090	81-003	83-013	79-099	80-141	83-058
78-002	81-013	83-026	79-114	80-152	83-069
78-024	81-014	83-068	79-115	81-032	83-070
78-028	81-036	83-082	79-116	81-044	83-073
78-052	81-048	83-093	79-127	81-070	83-079
78-096	81-051	83-094	79-129	81-073	83-081
79-002	81-063	83-106	79-133	81-082	83-107
79-004	81-064	83-126	79-138	81-084	83-122
			80-003	81-086	83-124
			80-009	81-088	83-143

*Event report filed for Unit 2 but also applicable to Unit 1

*Event report filed for Unit 1 but also applicable to Unit 2

TABLE 2

E. I. HATCH UNITS 1 & 2
HPCI SYSTEM FAULT EVENT REPORT SUMMARY

FAULT ITEM	NUMBER OF REPORTS		NUMBER OF FAULTS		NUMBER OF TIMES UNAVAILABLE	
	UNIT 1	UNIT 2	UNIT 1	UNIT 2	UNIT 1	UNIT 2
PRESSURE INSTRUMENTATION	24	36	24	36	3	8
(a) Barksdale	11	16	11	16	0	4
(b) Barton	8	18	8	18	3	2
(c) Static-O-Ring	3	2	3	2	0	2
(d) Other Manufacturer	2	-	2	-	0	-
HUMAN FACTOR	21	13	30	13	19	7
(a) Design	7	4	14	4	11	1
(b) Installation	-	1	-	1	-	0
(c) Maintenance	4	3	5	3	5	3
(d) Operation	-	2	-	2	-	2
(e) Procedure	9	3	9	3	1	1
(f) Unknown	1	-	2	-	2	-
VALVES	13	22	14	23	9	18
(a) Electrical	7	13	7	13	4	12
(b) Mechanical	6	7	7	8	5	4
(c) Unknown	-	2	-	2	-	2
TURBINE TRIP & THROTTLE SYSTEM	10	3	11	3	8	3
MISCELLANEOUS	13	13	13	14	10	5
(a) Auxiliary Oil Pump	2	2	2	2	2	2
(b) Flow Instrumentation	-	2	-	2	-	0
(c) Level Instrumentation	-	1	-	1	-	0
(d) Lube Oil	2	-	2	-	1	-
(e) Pipe Break	2	-	2	-	1	-
(f) Power (Battery)	-	1	-	1	-	1
(g) Power (Inverter)	-	1	-	1	-	0
(h) Pumps (Other than Aux. Oil)	-	1	-	1	-	1
(i) Room Cooler	1	-	1	-	0	-
(j) Supports	-	3	-	4	-	0
(k) Temperature Instrumentation	2	1	2	1	2	0
(l) Unknown	4	1	4	1	4	1

TABLE 3

E. I. HATCH UNITS 1 & 2
HPCI SYSTEM FAULT EVENT REPORT PROBABLE
CAUSE AND AVAILABILITY EFFECT SUMMARY

FAULT		SYSTEM EFFECT*					
ITEM	PROBABLE CAUSE	UNIT 1			UNIT 2		
		U	PA	A	U	PA	A
PRESSURE INSTRUMENTATION		3	4	17	8	0	28
(a) Barksdale	Component Interference	-	-	-	2	0	0
	Corrosion	-	-	-	0	0	2
	Diaphragm	-	-	-	0	0	1
	Fouled Contacts	-	-	-	2	0	0
	Setpoint Drift	0	1	10	0	0	9
(b) Barton	Bellows	3	0	0	-	-	-
	Microswitch	-	-	-	0	0	1
	Setpoint Drift	0	0	5	2	0	14
	Short	-	-	-	0	0	1
(c) Static-O-Ring	Diaphragm	-	-	-	1	0	0
	Dirt	0	1	0	-	-	-
	Setpoint Drift	0	0	2	-	-	-
	Short	-	-	-	1	0	0
(d) Other Manufacturer	Ice	0	1	0	-	-	-
	Setpoint Drift	0	1	0	-	-	-
HUMAN FACTOR		19	6	5	7	2	4
(a) Design	Loads - Check Valve Closure	-	-	-	0	1	0
	Loads - Nozzle	0	1	0	-	-	-
	Room Temperature Instr.	10	1	0	1	0	1
	Separation	0	1	0	0	0	1
	Setpoint (Pressure Instr.)	1	0	0	-	-	-
(b) Installation	Failure to Follow Design	-	-	-	0	0	1
(c) Maintenance	Bumped Cabinet	-	-	-	1	0	0
	Disconnected Wire	-	-	-	1	0	0
	Rupture Diaphragm	1	0	0	-	-	-
	Separated Wire	-	-	-	1	0	0
	Short (Electrical)	1	0	0	-	-	-
	Valve Alignment	2	0	0	-	-	-
	Valve Test	1	0	0	-	-	-

*U = Unavailable; PA = Probably Available; A = Available

TABLE 3 (Continued)

FAULT		SYSTEM EFFECT*					
ITEM	PROBABLE CAUSE	UNIT 1			UNIT 2		
		U	PA	A	U	PA	A
HUMAN FACTOR (Continued)							
(d) Operation	Failure to Follow Procedures	-	-	-	2	0	0
(e) Procedure	Administrative	0	0	1	-	-	-
	Calibration	0	1	0	1	1	1
	Construction	0	1	0	-	-	-
	Procedures (Operability)	1	0	0	-	-	-
	Testing (Operability)	0	1	4	-	-	-
(f) Unknown	Valve Alignment	2	0	0	-	-	-
VALVES		9	3	2	18	0	5
(a) Electrical	Aging	0	0	1	1	0	0
	Binding	0	1	0	1	0	0
	Environment	-	-	-	4	0	0
	Insulation	-	-	-	1	0	0
	Loose Connection	-	-	-	2	0	0
	Motor	-	-	-	1	0	0
	Short	1	0	0	-	-	-
	Switch	1	1	0	-	-	-
	Switch (Torque)	-	-	-	1	0	1
	Unknown	2	0	0	1	0	0
(b) Mechanical	Calibration	0	1	0	-	-	-
	Diaphragm	3	0	0	-	-	-
	Dirt	-	-	-	0	0	1
	Interference	1	0	0	-	-	-
	Pinion Key	-	-	-	0	0	1
	Piping	-	-	-	1	0	0
	Seals	-	-	-	2	0	1
	Seat	1	0	0	-	-	-
	Unknown	0	0	1	1	0	1
(c) Unknown	Unknown	-	-	-	2	0	0
TURBINE TRIP & THROTTLE SYSTEM		8	2	1	3	0	0
All Items Except Valves	Binding	0	0	1	-	-	-
	Calibration	1	0	0	1	0	0
	Clearance (High)	1	0	0	-	-	-
	Component (Damaged)	4	1	0	-	-	-

TABLE 3 (Continued)

FAULT		SYSTEM EFFECT*					
ITEM	PROBABLE CAUSE	UNIT 1			UNIT 2		
		U	PA	A	U	PA	A
TURBINE TRIP & THROTTLE SYSTEM (Continued)							
All Items Except Valves (Continued)	Component (Defective)	1	0	0	-	-	-
	Ramp Generator	-	-	-	2	0	0
	Undefined	1	0	0	-	-	-
	Wear	0	1	0	-	-	-
MISCELLANEOUS		10	2	1	5	3	6
(a) Auxiliary Oil Pump	Dirty Contacts	1	0	0	-	-	-
	Relay Coli	-	-	-	2	0	0
	Unknown	1	0	0	-	-	-
(b) Flow Instrumentation	Binding	-	-	-	0	1	0
	Unknown	-	-	-	0	1	0
(c) Level Instrumentation	Setpoint Drift	-	-	-	0	0	1
(d) Lube Oil	Environment	0	1	0	-	-	-
	Vibration	1	0	0	-	-	-
(e) Pipe Break	Unknown	1	1	0	-	-	-
(f) Power (Battery)	Ground	-	-	-	1	0	0
(g) Power (Inverter)	Setpoint Drift	-	-	-	0	0	1
(h) Pumps (Other than Aux. Oil)	Motor Coil	-	-	-	1	0	0
(i) Room Cooler	Unknown	0	0	1	-	-	-
(j) Supports	Water Hammer	-	-	-	0	1	3
(k) Temperature Instr.	Broken Wire	-	-	-	0	0	1
	Loose Connection	1	0	0	-	-	-
	Setpoint Drift	1	0	0	-	-	-
(l) Unknown	Unknown	4	0	0	1	0	0

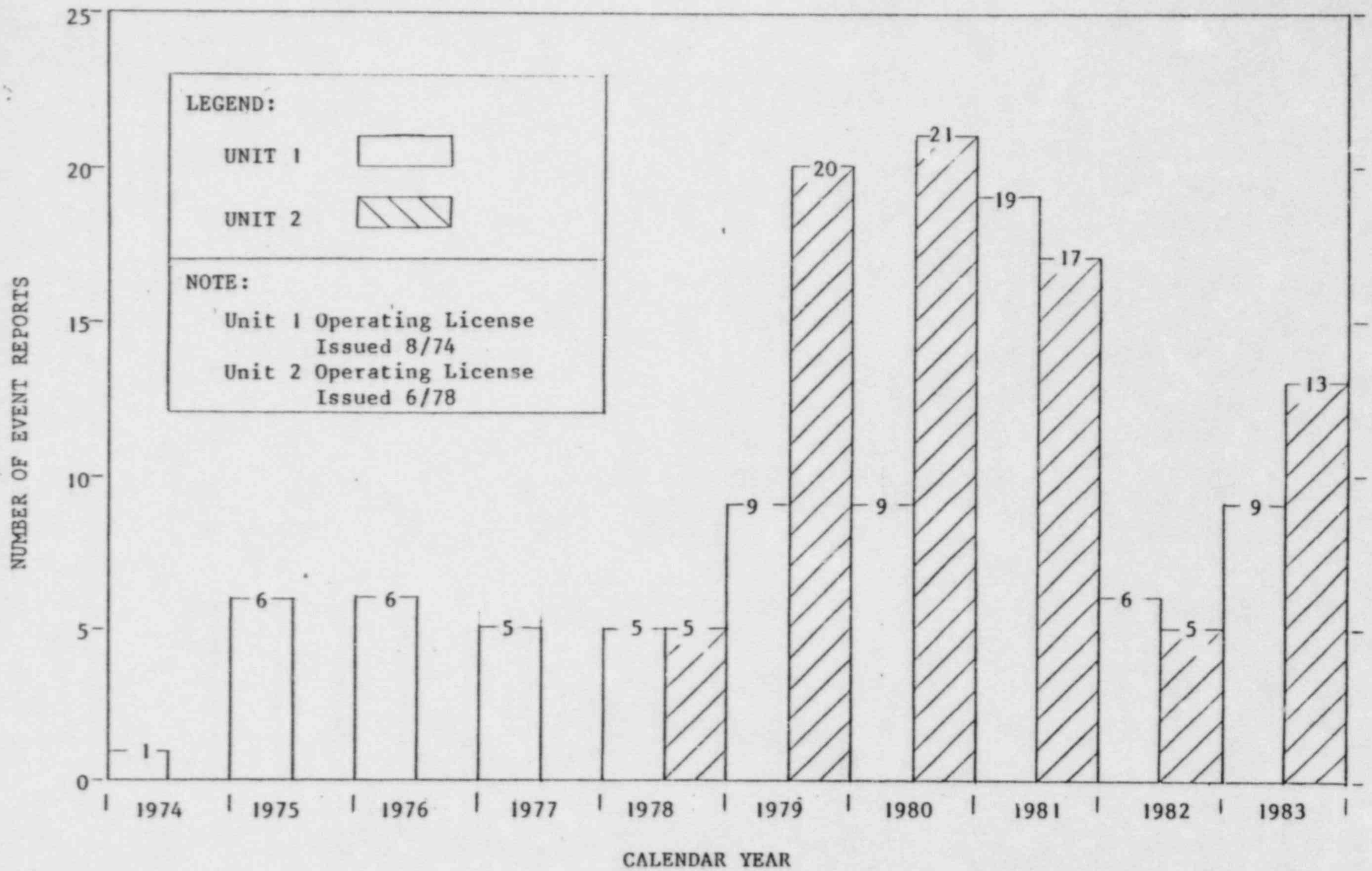

FIGURE 1: E. I. HATCH UNITS 1 & 2 - HPCI SYSTEM FAULT EVENT REPORTS YEARLY DISTRIBUTION

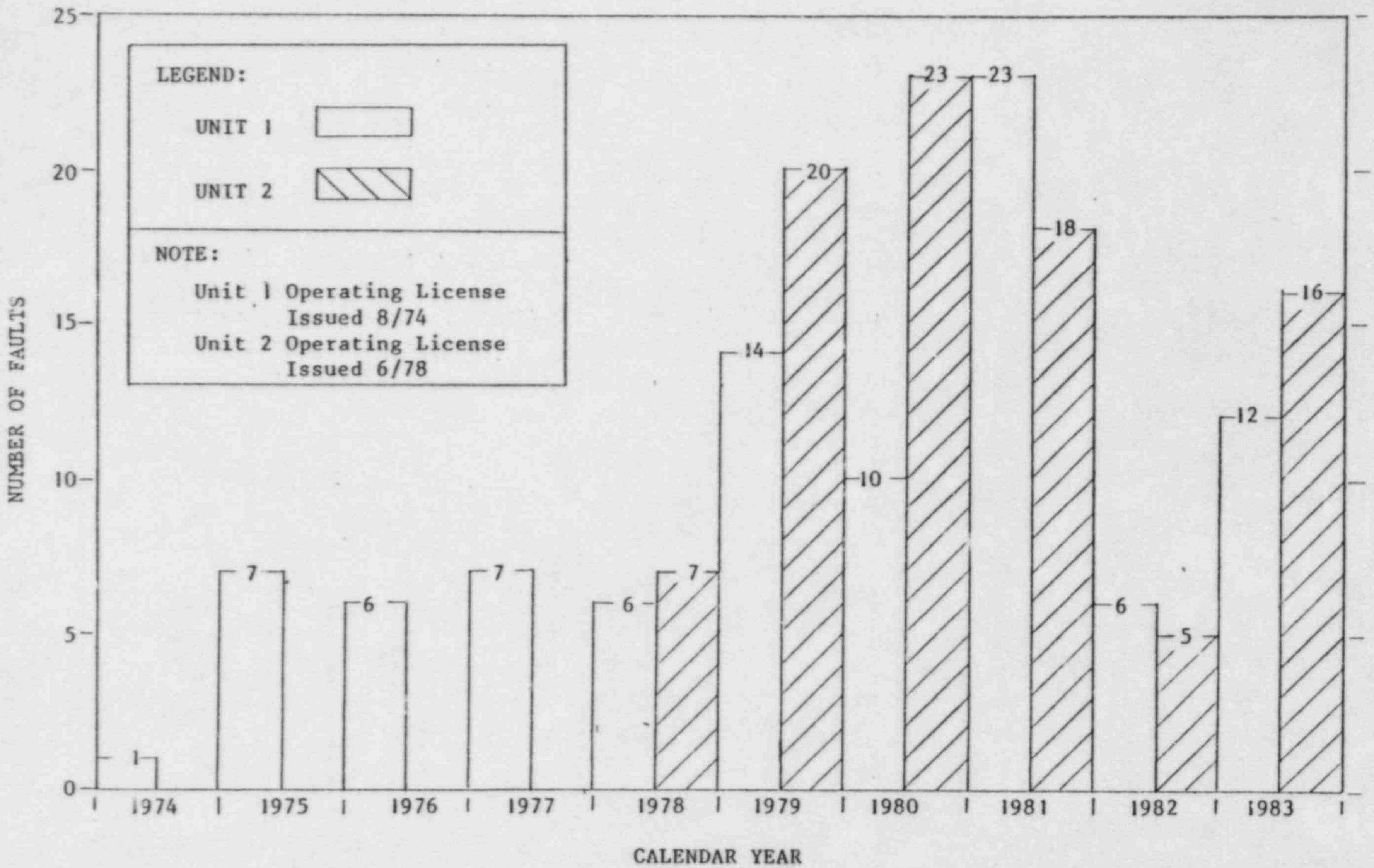

FIGURE 2: E. I. HATCH UNITS 1 & 2 - HPCI SYSTEM FAULT EVENTS YEARLY DISTRIBUTION

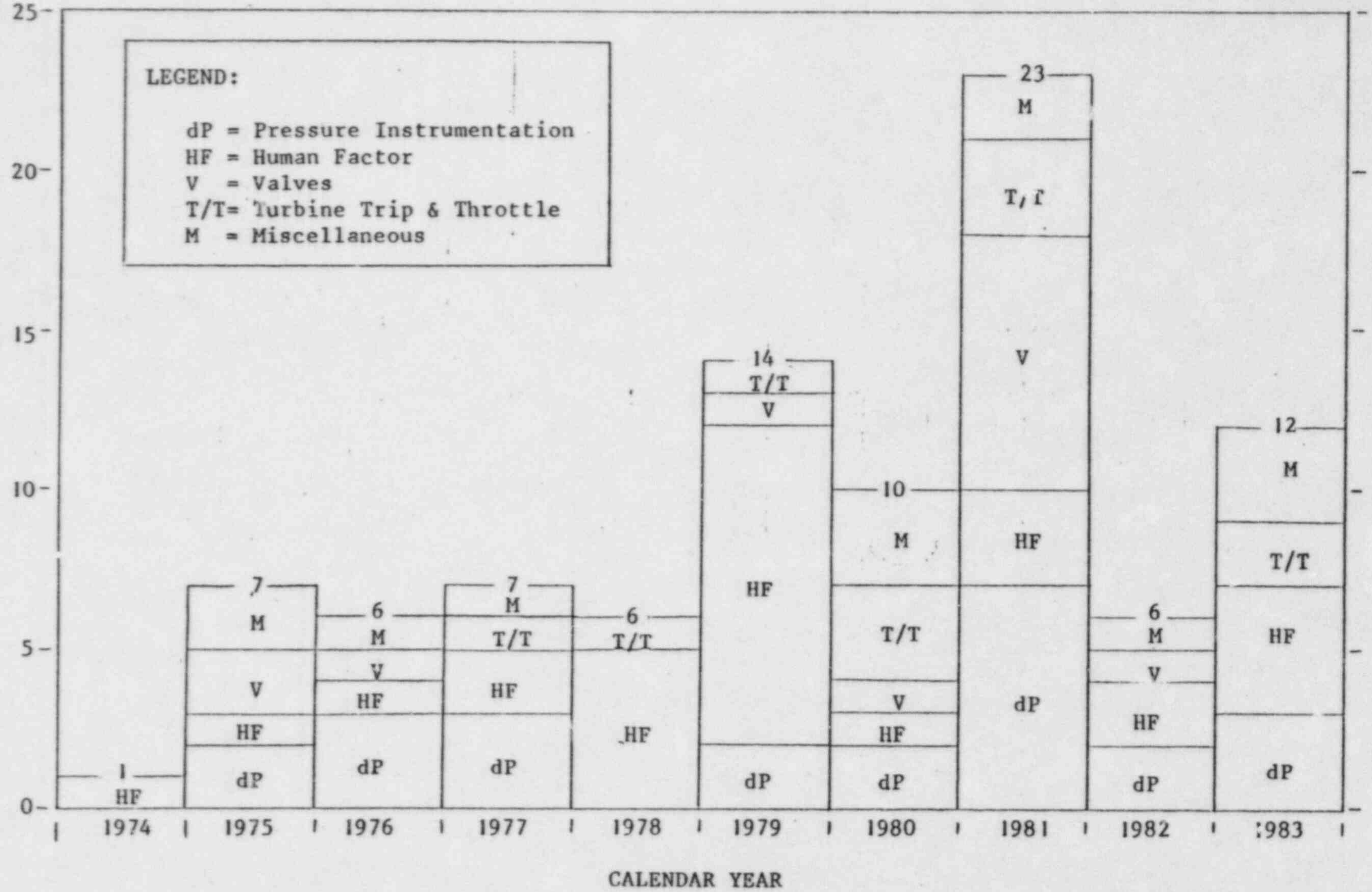

FIGURE 3: E. I. HATCH UNIT 1 - HPCI SYSTEM FAULT YEARLY DISTRIBUTION WITH ASSOCIATED FAULT CATEGORIES

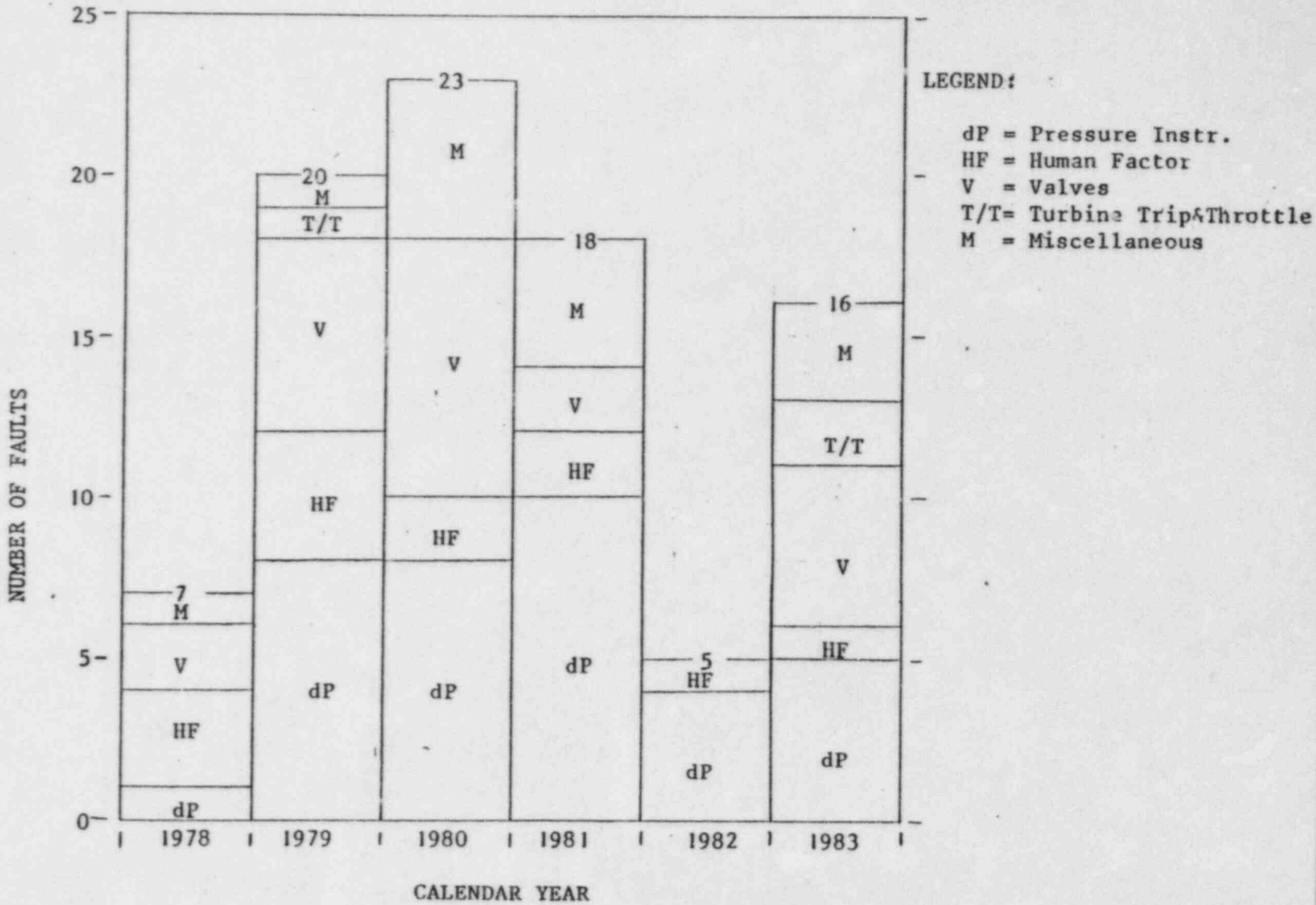

FIGURE 4: E. I. HATCH UNIT 2 - HPCI SYSTEM FAULT YEARLY DISTRIBUTION WITH ASSOCIATED FAULT CATEGORIES

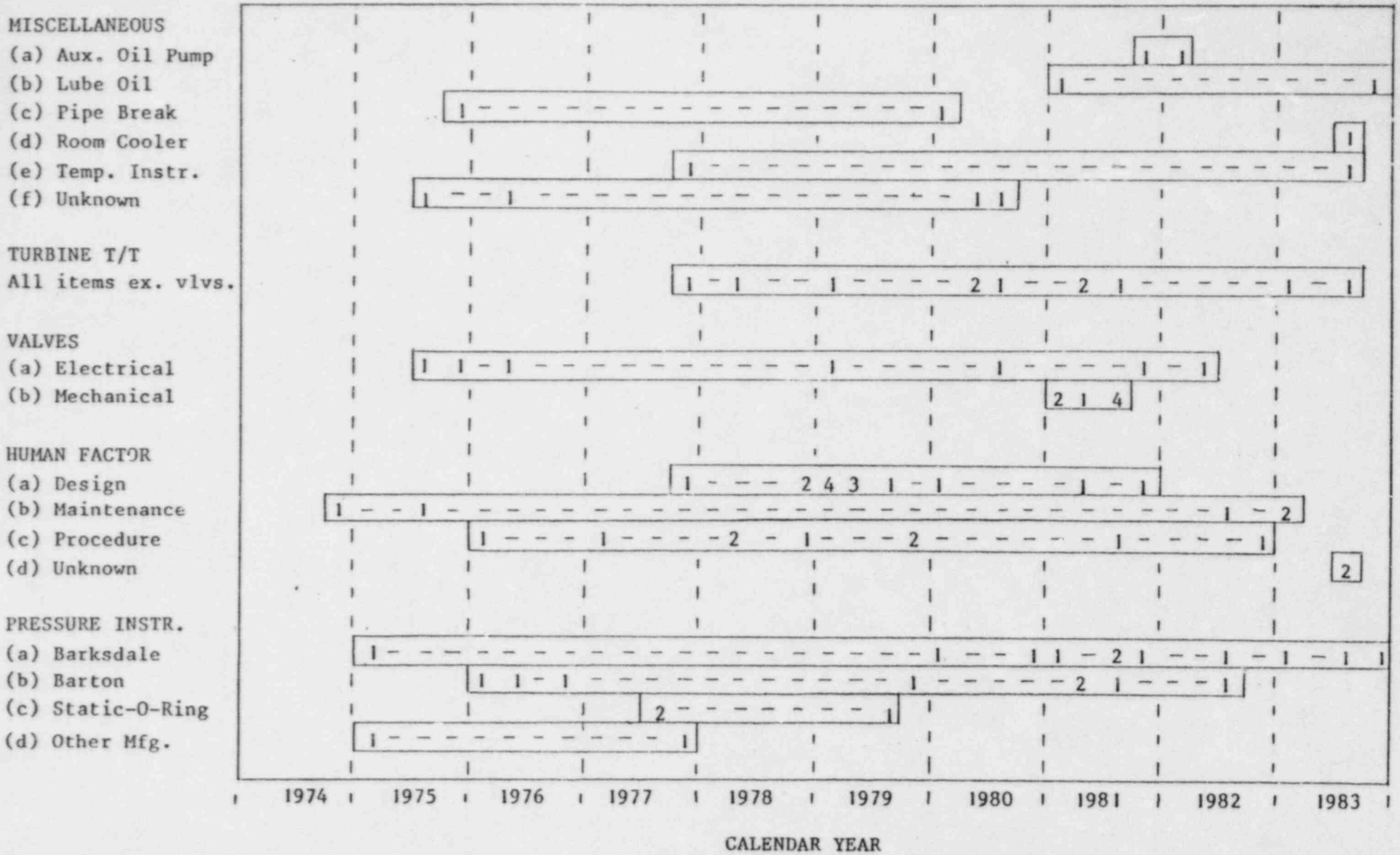

FIGURE 5: E. I. HATCH UNIT 1 - HPCI SYSTEM FAULT CATEGORY ITEMS CALENDAR QUARTER DISTRIBUTION

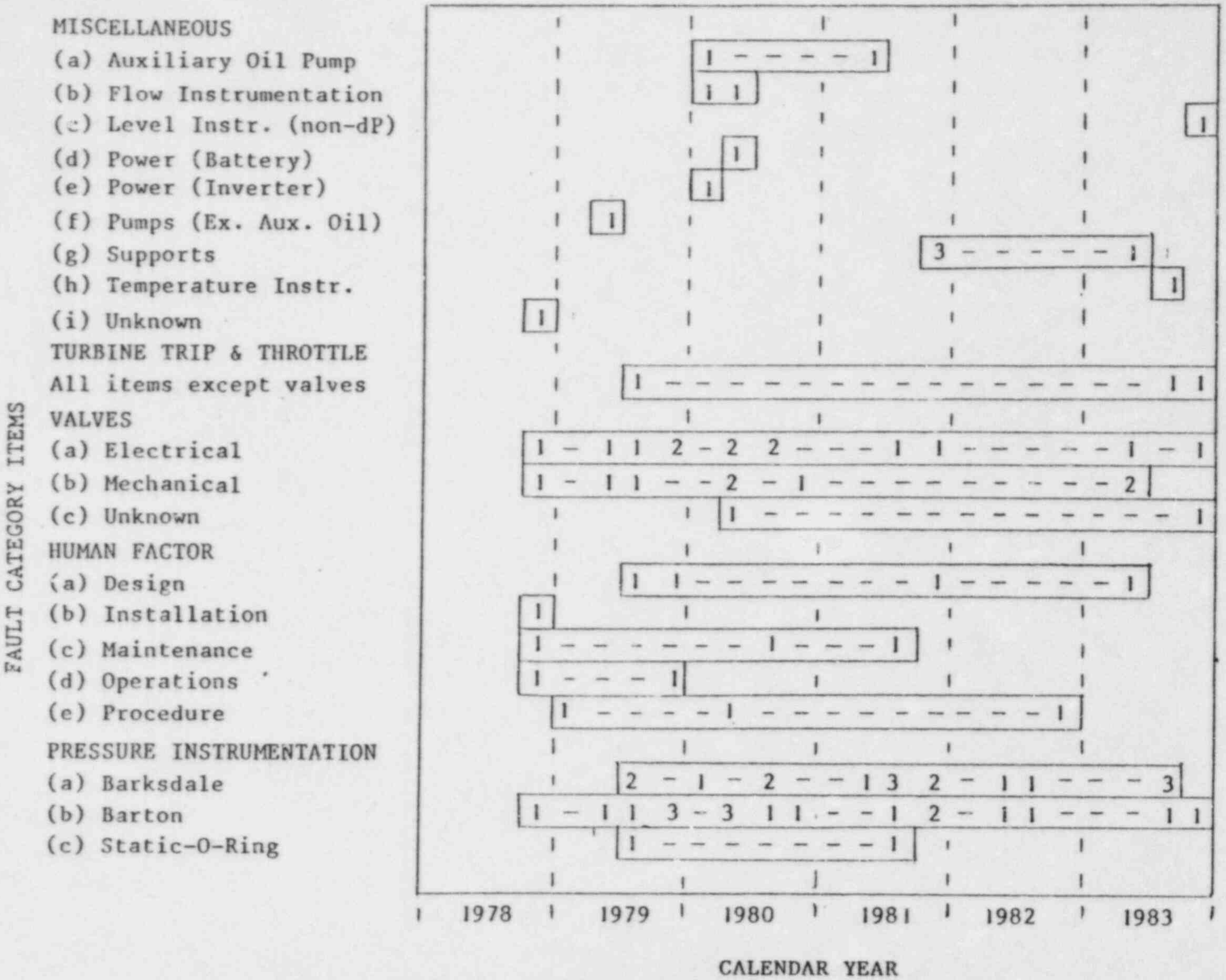

FIGURE 6: E. I. HATCH UNIT 2 - HPCI SYSTEM FAULT CATEGORY ITEMS CALENDAR QUARTERLY DISTRIBUTION

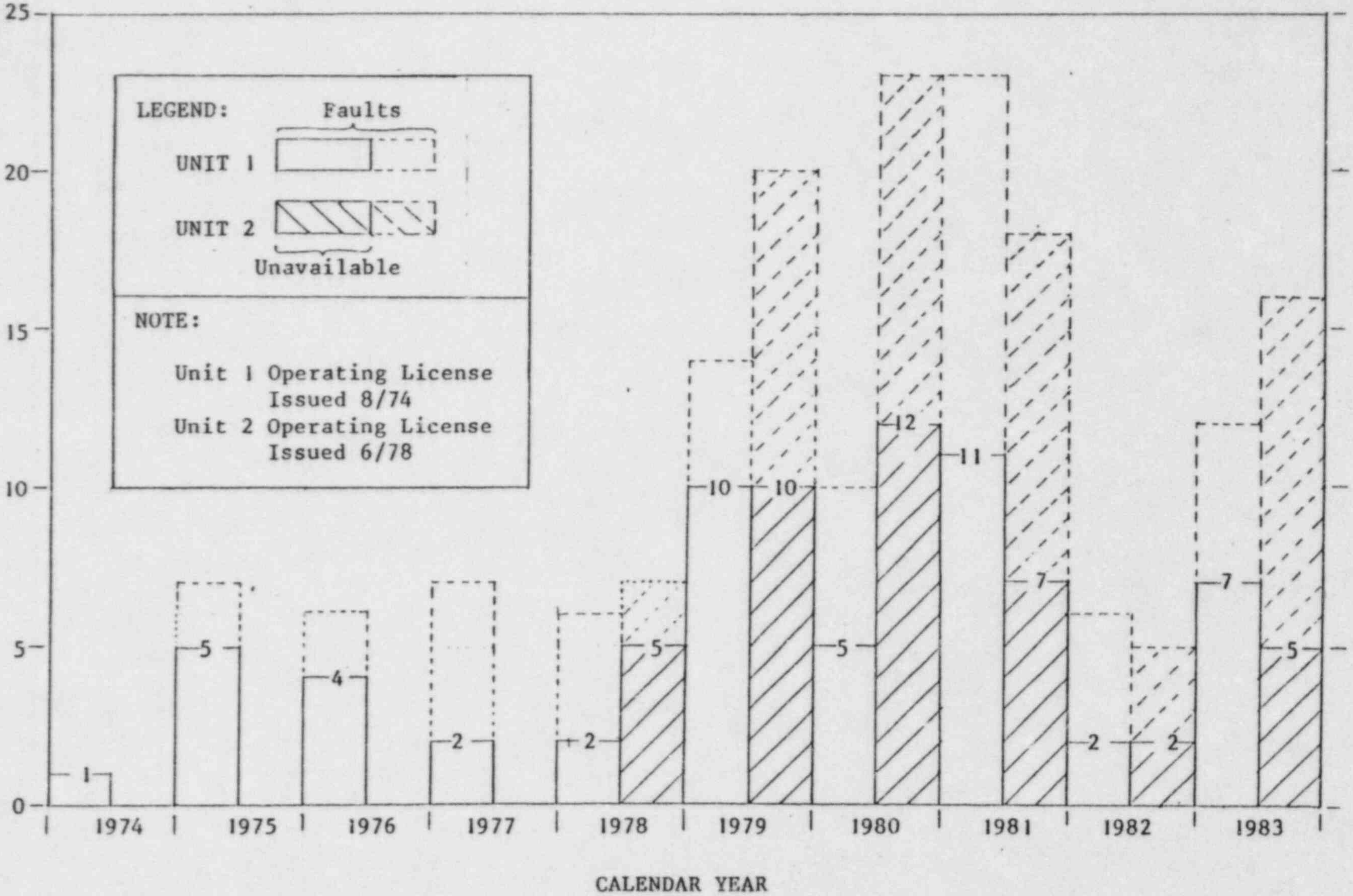

FIGURE 7: E. I. HATCH UNITS 1 & 2 - HPCI SYSTEM YEARLY SYSTEM UNAVAILABILITY DISTRIBUTION WITH ASSOCIATED FAULT DISTRIBUTION

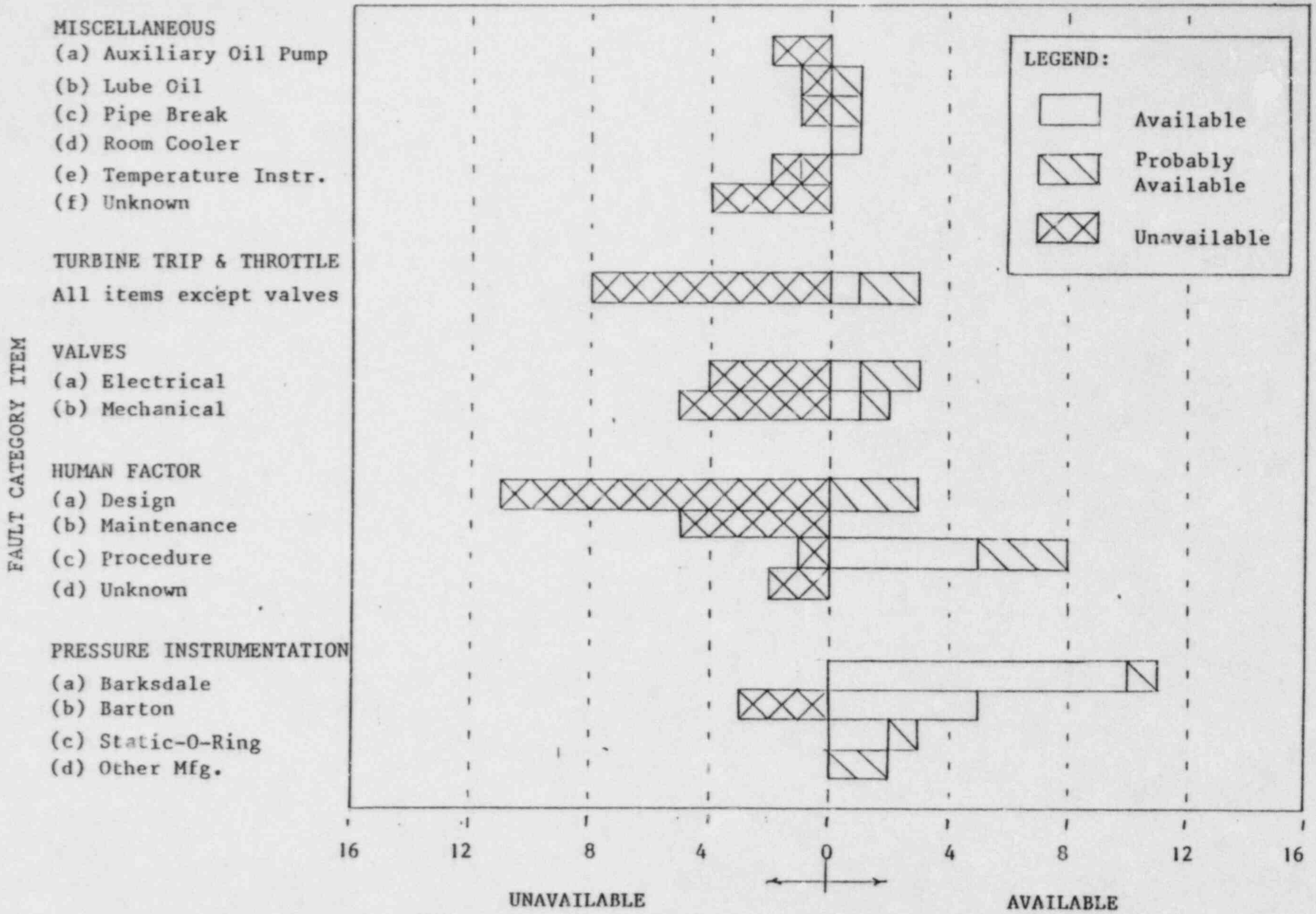

FIGURE 8: E. I. HATCH UNIT I - HPCI SYSTEM FAULT CATEGORY ITEMS SYSTEM AVAILABILITY EFFECT

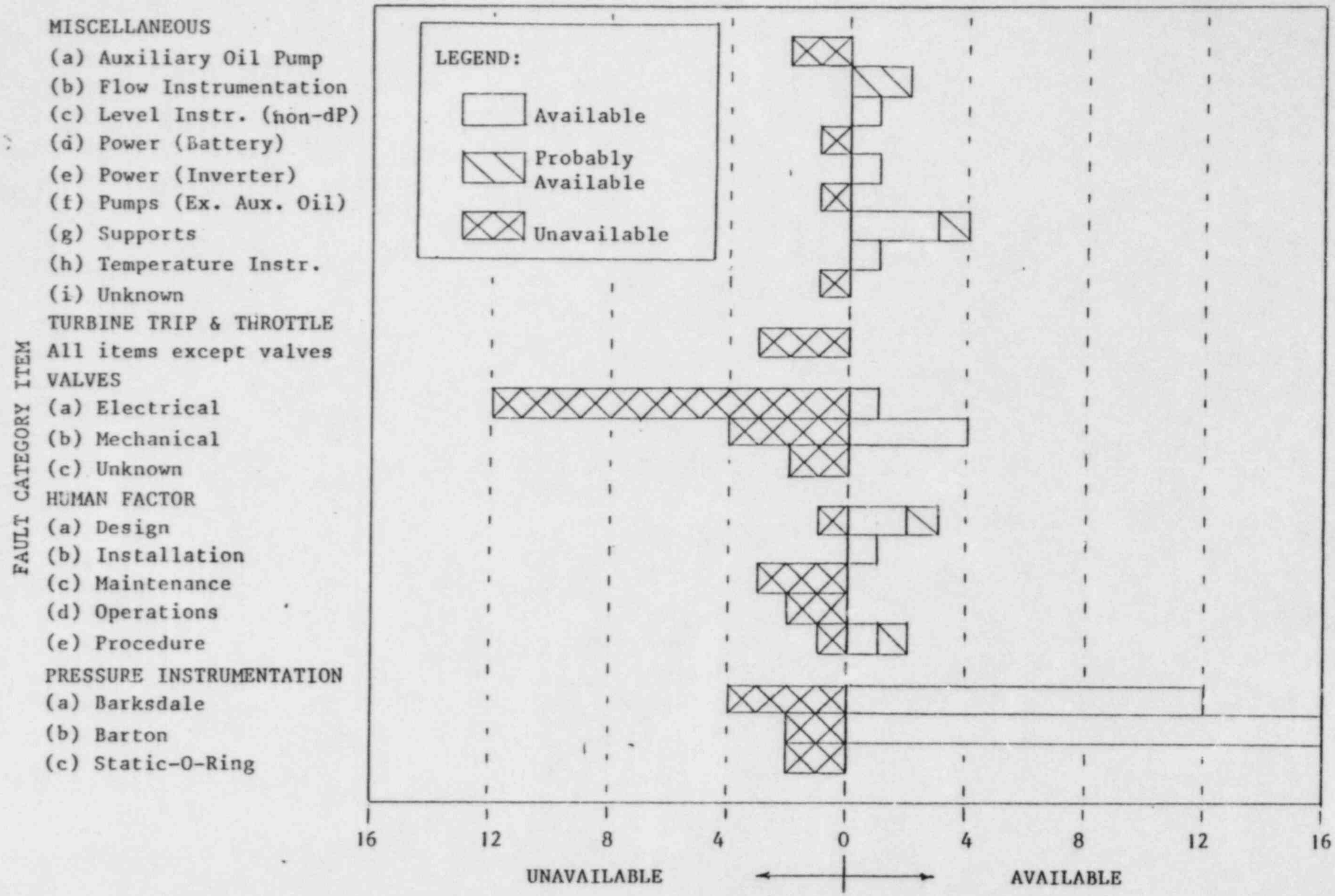

FIGURE 9: E. I. HATCH UNIT 2 - HPCI SYSTEM FAULT CATEGORY ITEMS SYSTEM AVAILABILITY EFFECT

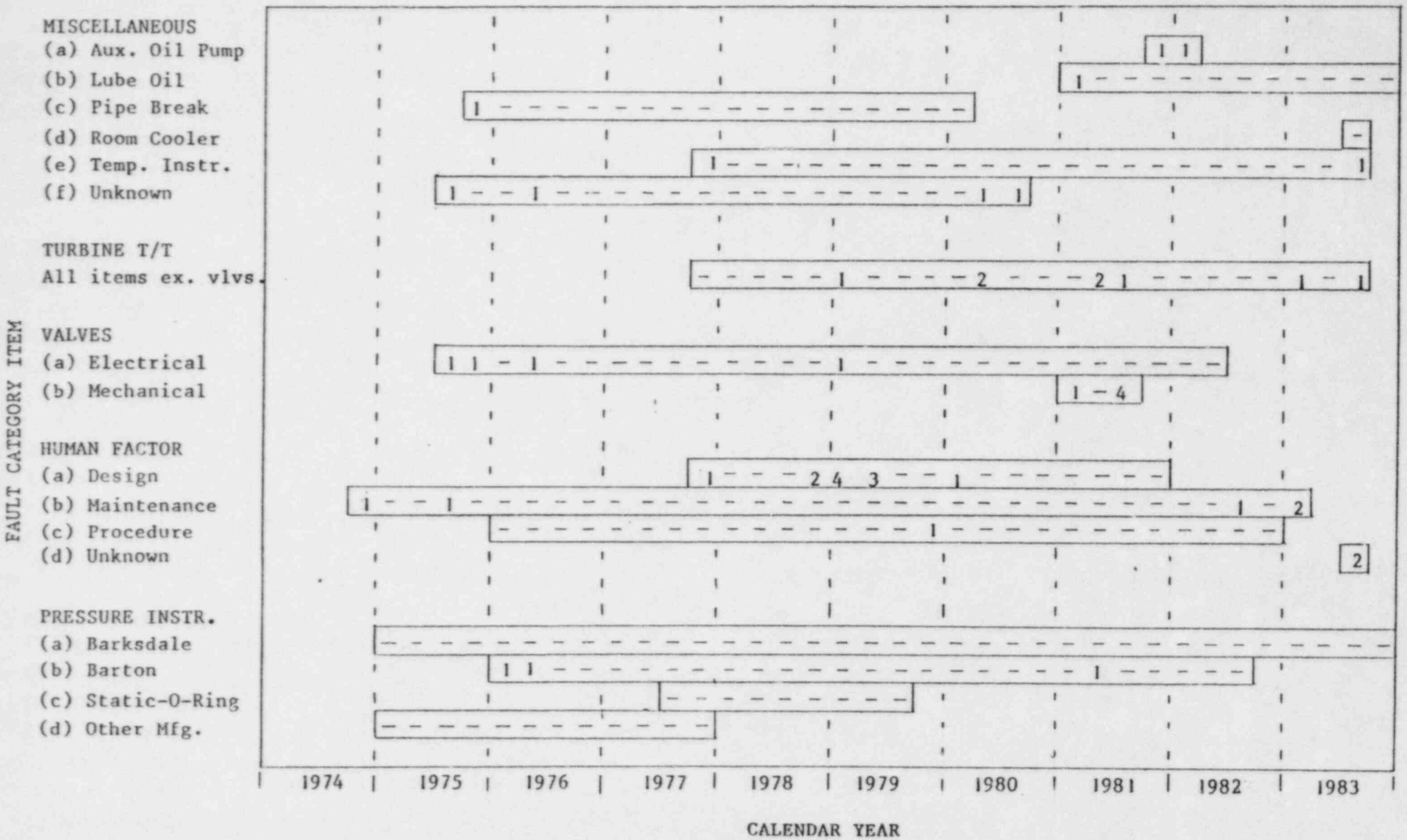

FIGURE 10: E. I. HATCH UNIT 1 - HPCI SYSTEM FAULT CATEGORY ITEMS CALENDAR QUARTERLY SYSTEM AVAILABILITY EFFECT

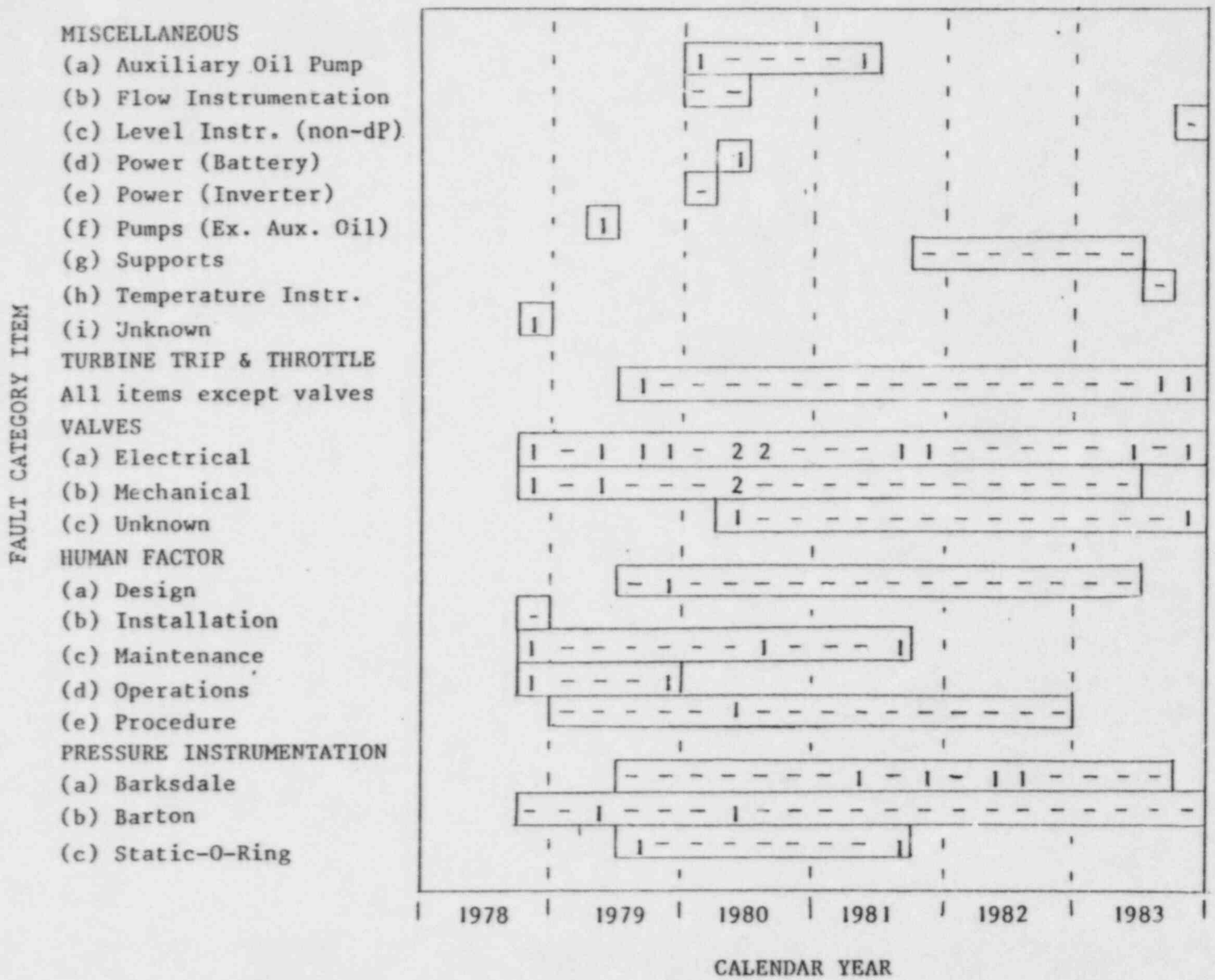

FIGURE 11: E. I. HATCH UNIT 2 - HPCI SYSTEM FAULT CATEGORY ITEMS CALENDAR QUARTERLY SYSTEM AVAILABILITY EFFECT