TRIGA Forced Shutdowns Analysis

Gheorghe Negut , Institute for Nuclear Research, Pitesti, Romania
Florica Laslau, Institute for Nuclear Research, Pitesti, Romania

1. Introduction

The need for a better operation lead us to use new methods and strategies. Probabilistic safety assesements and statistical analysis provide insights useful for our reactor operation. This paper is dedicated to analysis of the forced shutdowns during the first reactor opeation period between 1980 to 1989.

2. Forced shutdowns data base

The forced shutdowns data base was designed using data on forced shutdowns collected from the reactor operation logbooks.
In order to sort out the forced shutdown record have the following fields:
- current number
- date
- equipment failed
- failure type

M mechanical
E electrical
D irradiation device
U human failure

- scram mode

SE external scram, failure of reactor cooling circuits and /or irradiaton devices
SR reactor scram, exceeding of reactor nuclear parameters
SB reactor scram by control rod drop
SM manual scram required by the unfavorable reactor status

- scram cause

gives more information on the forced shutdown

This data base was processed using DBase III.

3. Data Processing

To sort out the data, one of the criteria was numbers of scrams per year, failure type, scram mode, etc.
In the Table 1 there are presented yearly scrams, total operation time in hours, total unavailable time, median unavailable time period, reactor diponibility Iu, reactor avalability A.
There were used the following formulae:
$Iu = Tf / Tt$
where:
Tf - total reactor operation time in hours
Tt - total hours per year
$A = Tf / (Tf + Tind)$
where:
Tind - total down time in hours

TABLE 1

YEAR	SCRAMS NUMBER	OPERAT TIME hours	UNAV TIME hours	MEDIAN UNAV hours	Iu	A
1980	8.	144.	12.1	1.51	0.0146	0.9224
1981	7.	218.	6.4	0.91	0.0248	0.9712
1982	206.	2940.2	471.55	2.27	0.3356	0.8617
1983	100.	2187.6	245.0	2.45	0.2497	0.8992
1984	58.	3014.0	462.5	7.97	0.3440	0.8669
1985	43.	5980.0	435.7	10.13	0.6828	0.9320
1986	46	4401.0	563.5	14.42	0.5023	0.8869
1987	49.	5149.0	767.0	15.65	0.5877	0.8703
1988	76.	6720.0	693.25	9.12	0.7671	0.9064
1989	47.	1807.0	524.25	11.15	0.2062	0.7751

In the figure 1 are presented the scrams per year in the 1980 to 1989 period. In the figure 2 thereare presented the reactor operation time per year. In the figure 3 there are presented the reactor down time per year and in the figure 4 operating time versus down time per year.
Total number of scrams in the covered period is 643 which caused a reactor down time of 4282.25 hours. In the Table 2 is shown the scrams based on the failure type.

TABLE 2

SCRAM TYPE	SCRAMS NUMBER	TOTAL DOWN TIME hours	MEDIAN DOWN TIME hours
ELECTRICAL	344	949.	2.76
MECHANICAL	19	158.	8.36
IRR DEVICES	273	3168.25	11.61
HUMAN	7	5.0	0.76
TOTAL	643	4282.25	6.84

In the figure 5 there are presented percentage of each type of failure from the total down time.
Based on the scram mode there are presented in the Table 3 scrams and the median down time.

TABLE 3

SCRAMS MODE	SCRAMS NUMBER	MEDIAN DOWN TIME
EXTERNAL	486	4.29
MANUAL	78	26.82
CONTROL ROD	15	0.70
REACTOR	46	2.76
FALSE	14	-

In the figure 6 it is presented te weight of each scram mode from the total scrams number.
In the Table 5 it is presented a comparison of the scrams from the electrical compared with those from the irradiation devices.

TABLE 4

YEAR	EL. SCR.	TOTAL TIME hours	MEDIAN TIME hours	IRR. SCR. hours	TOTAL TIME	MEDIAN TIME
1980	8	12.1	1.51	-	-	-
1981	3	2.1	0.70	2	1.0	0.5
1982	94	92.5	0.98	106	367.7	3.47
1983	77	116.8	1.52	77	34.3	2.02
1984	24	49.25	2.05	32	388. 7	16.15
1985	29	89.0	3.07	11	321.2	29.20
1986	18	30.0	1.67	27	633.0	23.44
1987	24	69.0	2.88	24	697.0	29.04
1988	37	361.25	9.76	36	327.5	9.10
1989	29	126.5	4.36	18	397.7	22.10

In the Table 5 there are presented the scrams depending on the equipment failed. There were established 3 categories: coolant circuit, reactor console and control rods, irradiation devices.

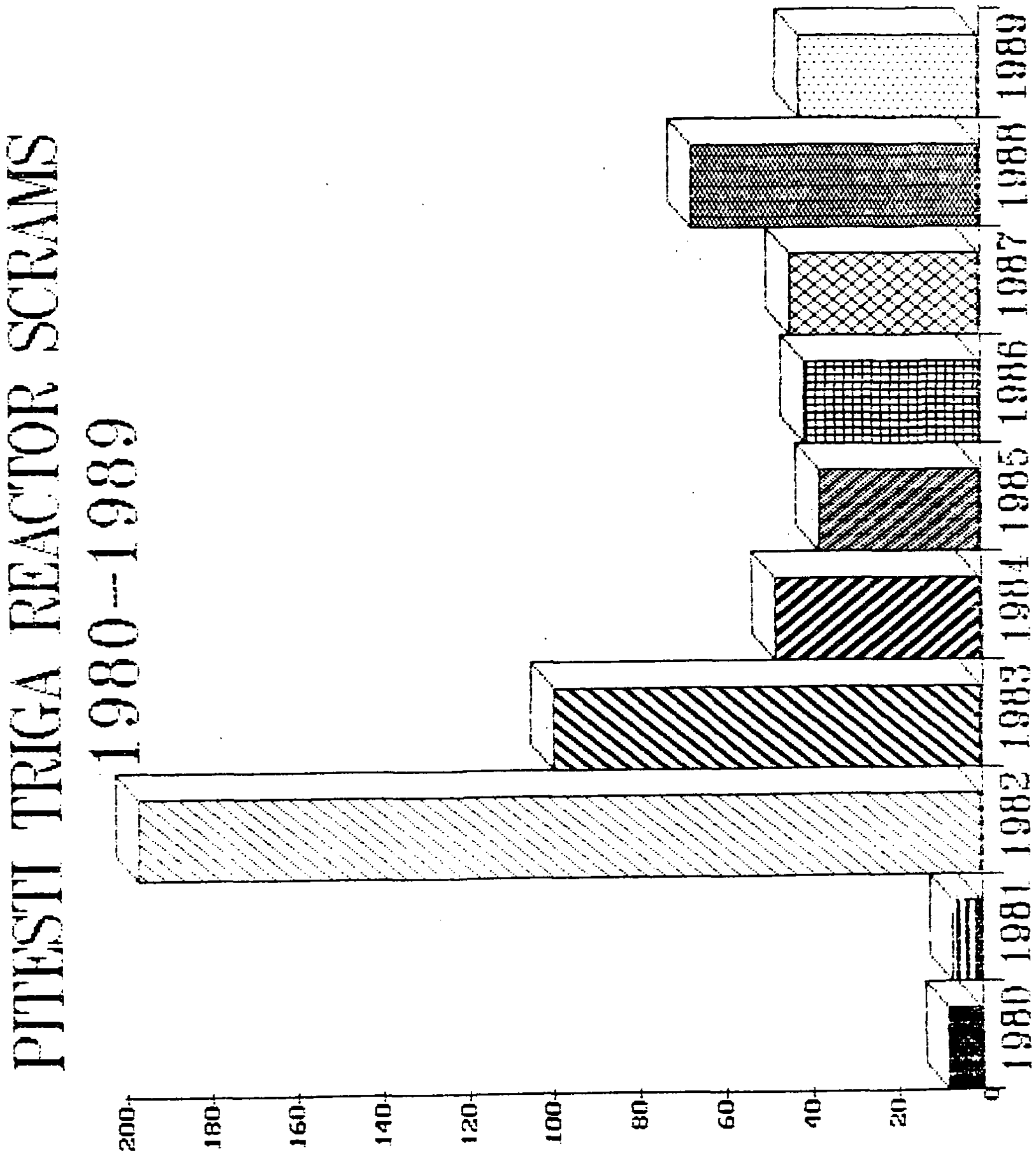
TABLE 5

FAILED EQUIP.	SCRAM NUMBER	UNAV TIME hours	MEDIAN DOWN TIME hours
COOLANT CIRCUIT			
RELAYS	207	291.87	1.41
PRIMARY PUMPS	35	50.40	1.44
EMERGENCY PUMP	38	600.40	15.80
SECONDARY PUMPS	1	1.00	1.00
GA TEMP.	1	1.00	1.00
FUSES	2	2.25	1.12
INVERTERS	2	8.24	4.12
COMPRESSED AIR	2	3.00	1.50
110 KV	3	3.00	1.00
TOTAL	**291**	**960.15**	
REACTOR			
CONTROL ROD	18	11.88	0.66
PWR CHAN.	12	13.44	1.12
CONSOLE	4	20.00	5.00
TEMPERAT. LOOP	28	84.00	3.05
REACTOR PERIOD	2	3.00	0.65
TOTAL	**64**	**130.00**	
IRRADIATION DEVICES			
LOOP A	62	1390.04	22.44
C 1	57	865.83	15.19
C 2	22	54.78	2.49
C3+C4	103	367.71	3.57
CAP LOOP	18	374.71	20.78
C5	4	5.52	1.38
C7	2	80.50	40.25
TOTAL	**273**	**3168.25**	

In the figure 7 it is presented the weight of each group of equipments of the total number of scrams and the figure 8 which shows the weight of this equipments in the reactor total down time. Figure 9 does a comparison between the down time caused by electrical and irradiation devices.

4. Conclusions

This study emphasized some problems and difficulties. One main difficulty to create this data base was the unstandardized scram record mode. Some times there were confused records about the cause or equipment. Some times wrong operator acrions were not duly recorded.Anyway it was tried to analyse objectively the cause.
From the data it can be observed that the most scrams take place in 1982, a number of 208 scrams. It have to emphasize that this was the first year to operate the reactor with irradiation devices. The scrams number began to lower thereafter and at the end of the eighties began to increase again. Anyway the greatest downtime was recorded in 1987, but the availability of this reactor was almost constant. The greatest number of the scrams were cause by the reactor electricai, control and instrumentation 344. An important number of scrams were caused by the irradiation devices 273, which caused a total reactor down time of 3168 hours. So this is the main cause for unavailabilty for this reactor. It is also intreresting that the 110 KV grid frequency find in this data base is comparable in value with that used in our PSA studies. The insights are useful to our operational procedures, to improve the maintenance stratrategy and the logbook recording.



1980-1989

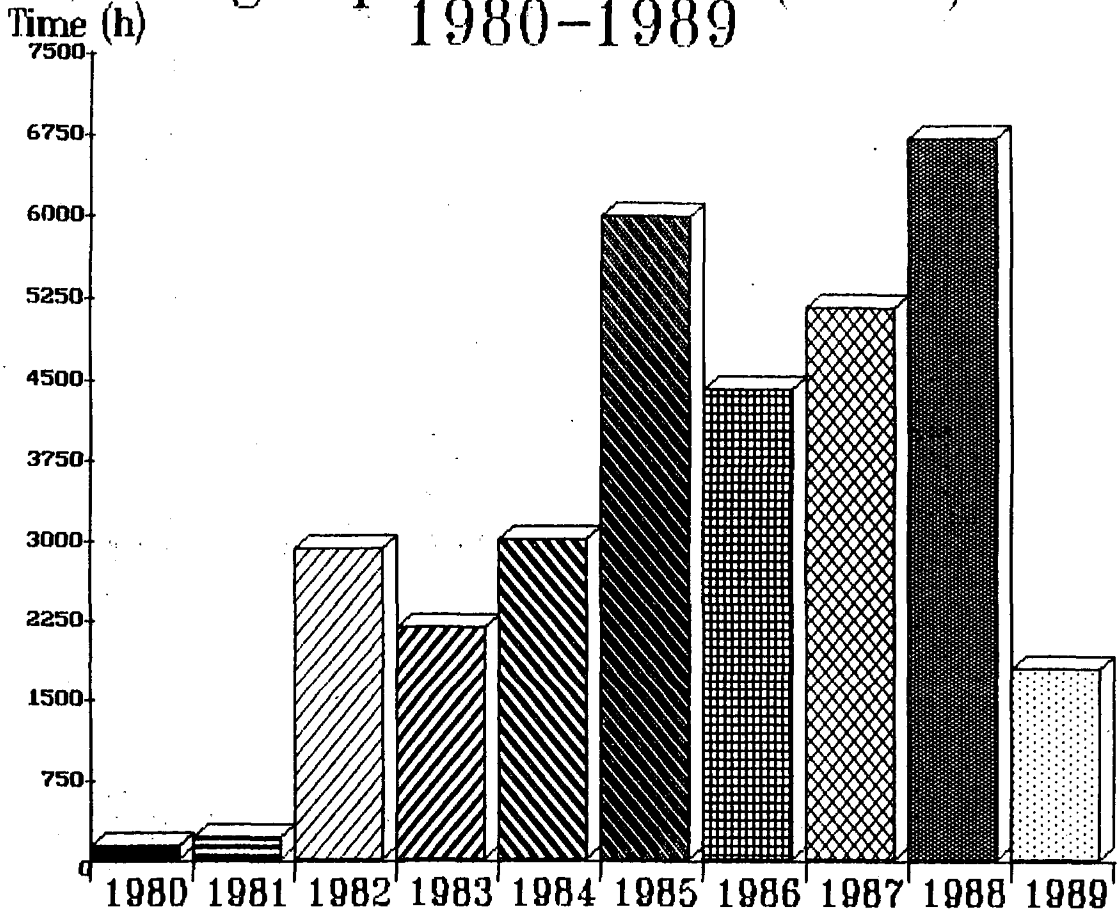


FIGURE 2

TRIGA DOWN TIME (HOURS)
1980-1989

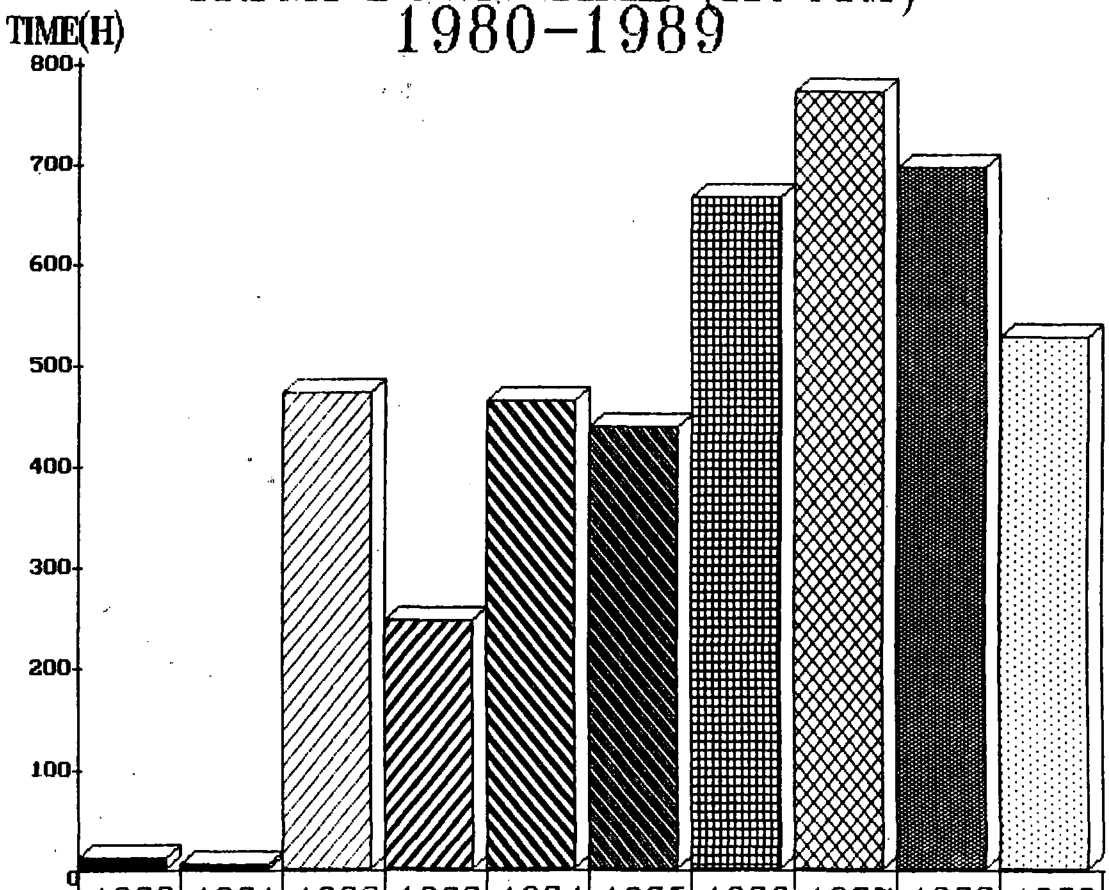


FIGURE 3

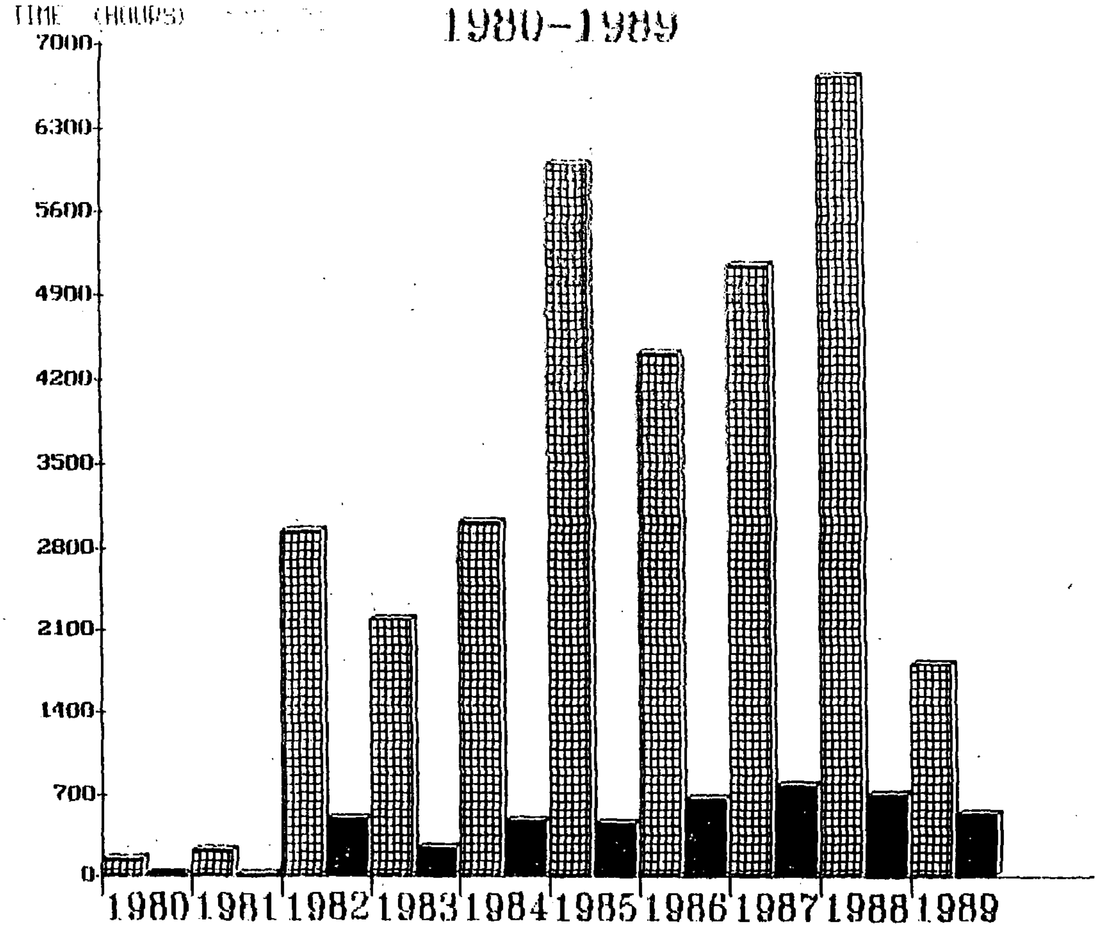
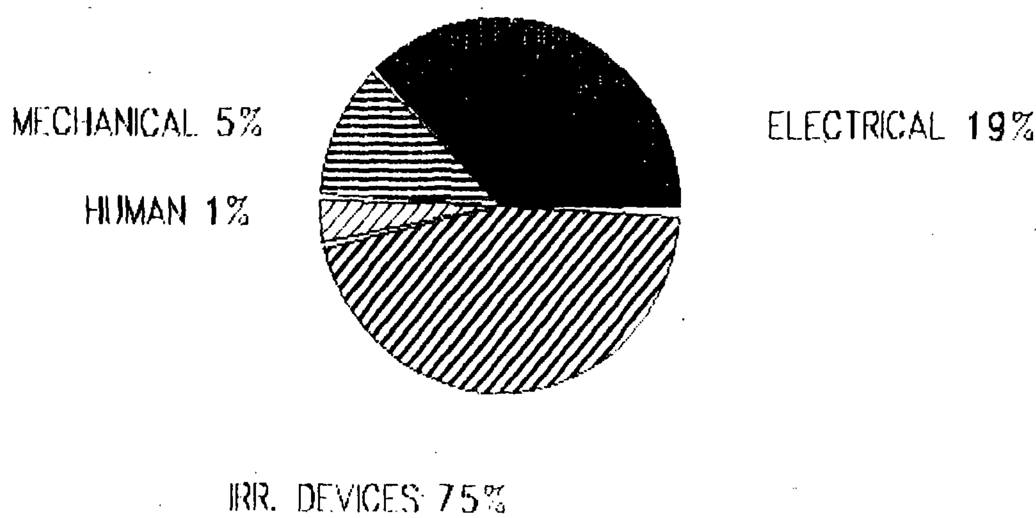


FIGURE 4

DOWN TIME



FORCED SHUTDOWNS

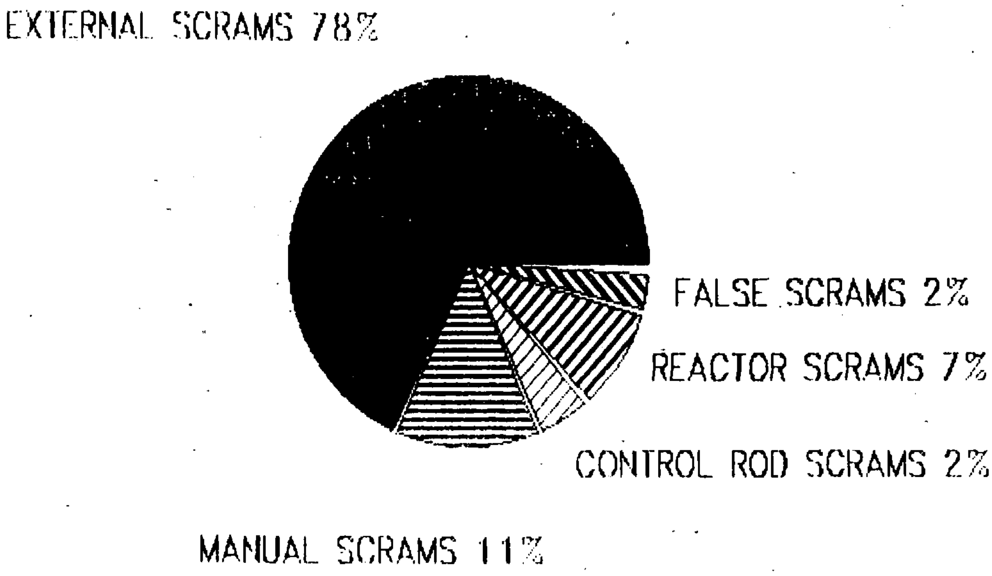


FIGURE 6

EQUIPMENT FAILURES

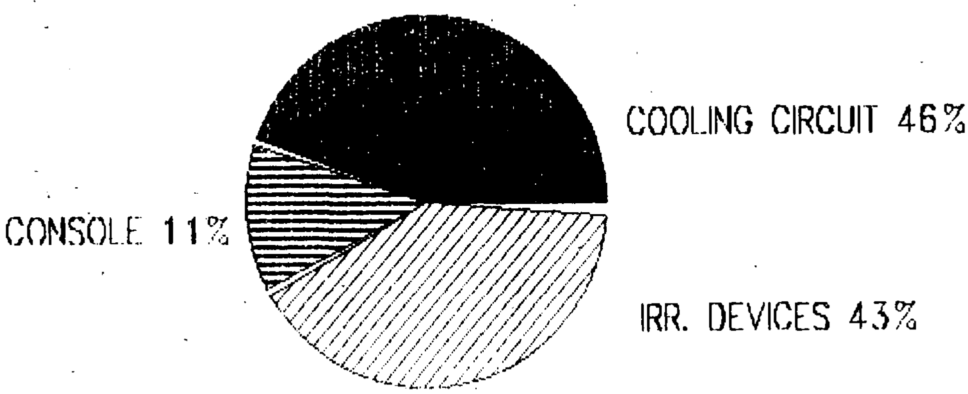


FIGURE 7

DOWN TIME

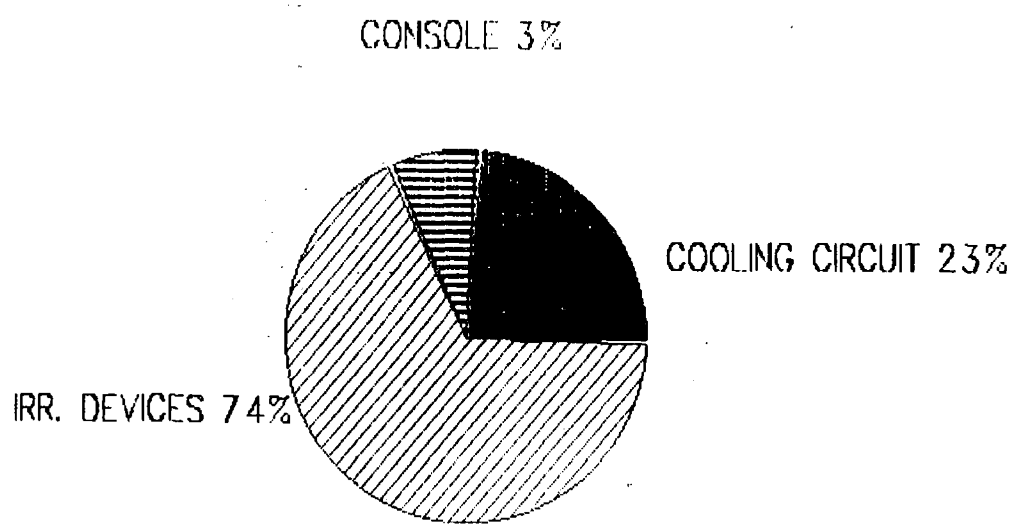


FIGURE 8

DOWN TIME ELECTRICAL/IRR. DEVICES 1980-1989

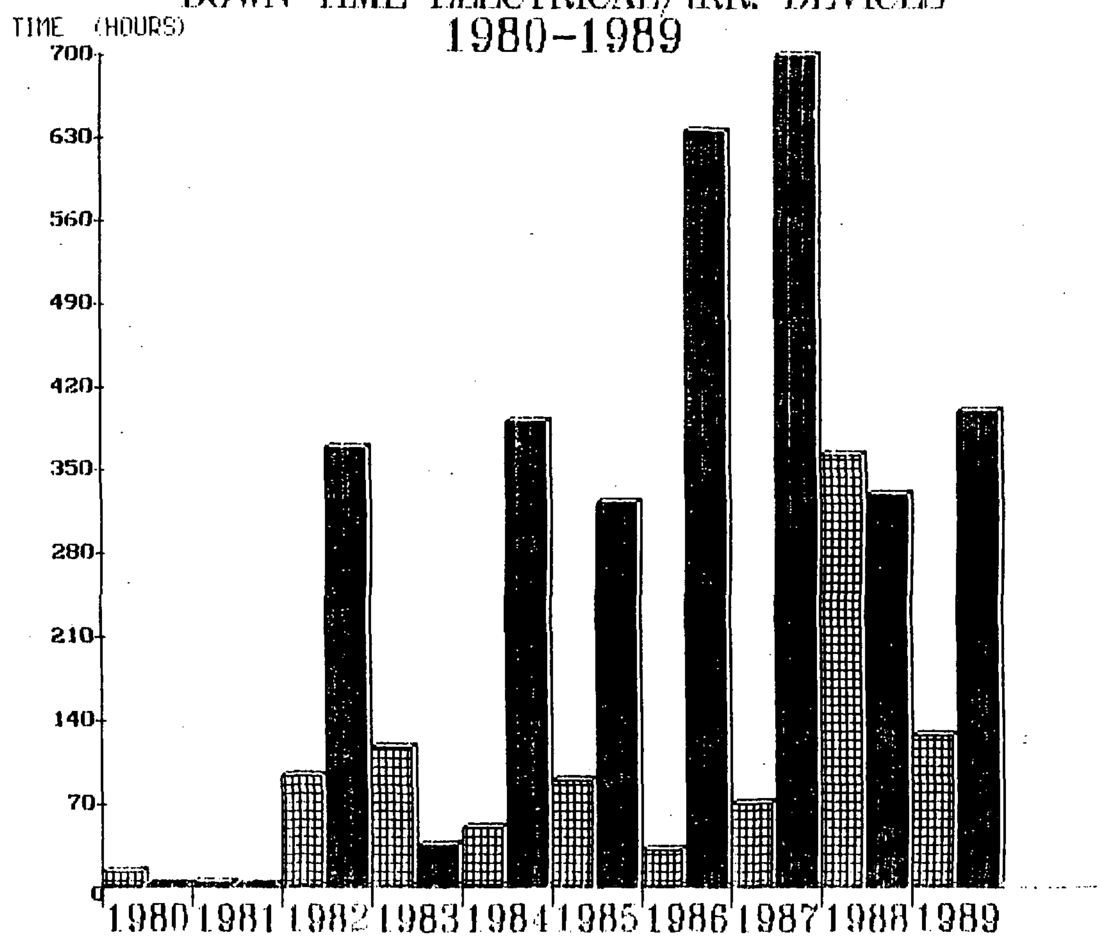


FIGURE 9