

APPENDIX F

METHODOLOGIES FOR COMPUTING THE UNAVAILABILITY INDEX, THE UNRELIABILITY INDEX AND DETERMINING PERFORMANCE INDEX VALIDITY

This appendix provides the details of three calculations, calculation of the System Unavailability Index, the System Unreliability Index, and the criteria for determining when the Mitigating System Performance Index is unsuitable for use as a performance index.

System Unavailability Index (UAI) Due to Changes in Train Unavailability

Calculation of System UAI due to changes in train unavailability is as follows:

$$UAI = \sum_{j=1}^n UAI_j \quad \text{Eq. 1}$$

where the summation is over the number of trains (n) and UAI_j is the unavailability index for a train.

Calculation of UAI_j for each train due to changes in train unavailability is as follows:

$$UAI_j = CDF_p \left[\frac{FV_{UA_p}}{UA_p} \right]_{\max} (UA_j - UA_{BL}), \quad \text{Eq. 2}$$

where:

CDF_p is the plant-specific, internal events, at power Core Damage Frequency,

FV_{UA_p} is the train-specific Fussell-Vesely value for unavailability,

UA_p is the plant-specific PRA value of unavailability for the train,

UA_j is the actual unavailability of train t , defined as:

$$UA_j = \frac{\text{Unavailable hours during the previous 12 quarters while critical}}{\text{Critical hours during the previous 12 quarters}}$$

and,

UA_{BL} is the historical baseline unavailability value for the train determined as described below.

UA_{BL} is the sum of two elements: planned and unplanned unavailability. Planned unavailability is the actual, plant-specific three-year total planned unavailability for the train for the years 1999 through 2001 (see clarifying notes for details).

This period is chosen as the most representative of how the plant intends to perform routine maintenance and surveillances at power. Unplanned unavailability is the historical industry average for unplanned unavailability for

1 the years 1999 through 2001. See Table 1 for historical train values for
 2 unplanned unavailability.

3 Calculation of the quantity inside the square bracket in equation 2 will be discussed at the
 4 end of the next section. See clarifying notes for calculation of UAI for cooling water
 5 support system.

6

7 **System Unreliability Index (URI) Due to Changes in Component Unreliability**

8 Unreliability is monitored at the component level and calculated at the system level.

9 Calculation of system URI due to changes in component unreliability is as follows:

10
$$URI = CDF_p \sum_{j=1}^m \left[\frac{FV_{URcj}}{UR_{pcj}} \right]_{\max} (UR_{Bcj} - UR_{BLcj}) \quad \text{Eq. 3}$$

11 Where the summation is over the number of active components (*m*) in the system, and:

12 *CDF_p* is the plant-specific internal events, at power, core damage frequency,

13 *FV_{URc}* is the component-specific Fussell-Vesely value for unreliability,

14 *UR_{pc}* is the plant-specific PRA value of component unreliability,

15 *UR_{Bc}* is the Bayesian corrected component unreliability for the previous 12
 16 quarters,

17 and

18 *UR_{BLc}* is the historical industry baseline calculated from unreliability mean values
 19 for each monitored component in the system. The calculation is performed in a
 20 manner similar to equation 4 below using the industry average values in Table 2.

21 Calculation of the quantity inside the square bracket in equation 3 will be discussed at the
 22 end of this section.

23 Component unreliability is calculated as follows.

24
$$UR_{Bc} = P_D + \lambda T_m \quad \text{Eq 4}$$

25 where:

26 *P_D* is the component failure on demand probability calculated based on data
 27 collected during the previous 12 quarters,

28 *λ* is the component failure rate (per hour) for failure to run calculated based on
 29 data collected during the previous 12 quarters,

30 and

31 *T_m* is the risk-significant mission time for the component based on plant specific
 32 PRA model assumptions. Add acceptable methodologies for determining mission
 33 time.

34

1 NOTE:

2 For valves only the P_D term applies

3 For pumps $P_D + \lambda T_m$ applies

4 For diesels $P_{D\text{ start}} + P_{D\text{ load run}} + \lambda T_m$ applies

5

6 The first term on the right side of equation 4 is calculated as follows.¹

$$7 \quad P_D = \frac{(N_d + a)}{(a + b + D)} \quad \text{Eq. 5}$$

8 where:

9 N_d is the total number of failures on demand during the previous 12 quarters,

10 D is the total number of demands during the previous 12 quarters (actual ESF
 11 demands plus estimated test and estimated operational/alignment demands. An
 12 update to the estimated demands is required if a change to the basis for the
 13 estimated demands results in a >25% change in the estimate),

14 and

15 a and b are parameters of the industry prior, derived from industry experience (see
 16 Table 2).

17 In the calculation of equation 5 the numbers of demands and failures is the sum of all
 18 demands and failures for similar components within each system. Do not sum across
 19 units for a multi-unit plant. For example, for a plant with two trains of Emergency Diesel
 20 Generators, the demands and failures for both trains would be added together for one
 21 evaluation of P_D which would be used for both trains of EDGs.

22 In the second term on the right side of equation 4, λ is calculated as follows.

$$23 \quad \lambda = \frac{(N_r + a)}{(T_r + b)} \quad \text{Eq. 6}$$

24 where:

25 N_r is the total number of failures to run during the previous 12 quarters,

26 T_r is the total number of run hours during the previous 12 quarters (actual ESF run
 27 hours plus estimated test and estimated operational/alignment run hours. An
 28 update to the estimated run hours is required if a change to the basis for the
 29 estimated hours results in a >25% change in the estimate).

30 and

¹ Atwood, Corwin L., Constrained noninformative priors in risk assessment, *Reliability Engineering and System Safety*, 53 (1996; 37-46)

1 *a* and *b* are parameters of the industry prior, derived from industry experience (see
2 Table 2).

3 In the calculation of equation 6 the numbers of demands and run hours is the sum of all
4 run hours and failures for similar components within each system. Do not sum across
5 units for a multi-unit plant. For example, a plant with two trains of Emergency Diesel
6 Generators, the run hours and failures for both trains would be added together for one
7 evaluation of λ which would be used for both trains of EDGs.

8 Fussell-Vesely, Unavailability and Unreliability

9 Equations 2 and 3 include a term that is the ratio of a Fussell-Vesely importance value
10 divided by the related unreliability or unavailability. Calculation of these quantities is
11 generally complex, but in the specific application used here, can be greatly simplified.

12 The simplifying feature of this application is that only those components (or the
13 associated basic events) that can fail a train are included in the performance index.
14 Components within a train that can each fail the train are logically equivalent and the
15 ratio FV/UR is a constant value for any basic event in that train. It can also be shown that
16 for a given component or train represented by multiple basic events, the ratio of the two
17 values for the component or train is equal to the ratio of values for any basic event within
18 the train. Or:

19
$$\frac{FV_{be}}{UR_{be}} = \frac{FV_{URc}}{UR_{Pc}} = \frac{FV_t}{UR_t} = \text{Constant}$$

20 and

21
$$\frac{FV_{be}}{UA_{be}} = \frac{FV_{UAp}}{UA_p} = \text{Constant}$$

22 Note that the constant value may be different for the unreliability ratio and the
23 unavailability ratio because the two types of events are frequently not logically
24 equivalent. For example recovery actions may be modeled in the PRA for one but not the
25 other.

26 Thus, the process for determining the value of this ratio for any component or train is to
27 identify a basic event that fails the component or train, determine the failure probability
28 or unavailability for the event, determine the associated FV value for the event and then
29 calculate the ratio. Use the basic event in the component or train with the largest failure
30 probability (hence the maximum notation on the bracket) to minimize the effects of
31 truncation on the calculation. Exclude common cause events, which are not within the
32 scope of this performance index

33 Some systems have multiple modes of operation, such as PWR HPSI systems that operate
34 in injection as well as recirculation modes. In these systems all active components are not
35 logically equivalent, unavailability of the pump fails all operating modes while
36 unavailability of the sump suction valves only fails the recirculation mode. In cases such

1 as these, if unavailability events exist separately for the components within a train, the
 2 appropriate ratio to use is the maximum.

3 **Determination of systems for which the performance index is not valid**

4 The performance index relies on the existing testing programs as the source of the data
 5 that is input to the calculations. Thus, the number of demands in the monitoring period is
 6 based on the frequency of testing required by the current test programs. In most cases this
 7 will provide a sufficient number of demands to result in a valid statistical result.

8 However, in some cases, the number of demands will be insufficient to resolve the
 9 change in the performance index (1.0×10^{-6}) that corresponds to movement from a green
 10 performance to a white performance level. In these cases, one failure is the difference
 11 between baseline performance and performance in the white performance band. The
 12 performance index is not suitable for monitoring such systems and monitoring is
 13 performed through the inspection process.

14 This section will define the method to be used to identify systems for which the
 15 performance index is not valid, and will not be used.

16 The criteria to be used to identify an invalid performance index is:

17 If, for any failure mode for any component in a system, the risk increase
 18 (Δ CDF) associated with the change in unreliability resulting from single
 19 failure is larger than 1.0×10^{-6} , then the performance index will be
 20 considered invalid for that system.

21 The increase in risk associated with a component failure is the sum of the contribution
 22 from the decrease in calculated reliability as a result of the failure and the decrease in
 23 availability resulting from the time required to affect the repair of the failed component.
 24 The change in CDF that results from a demand type failure is given by:

25

26
$$MSPI = CDF_p \times \sum_{N \text{ similar comp}} \left\{ \frac{FV_{URc}}{UR_{pc}} \times \frac{1}{a+b+D} \right\}$$

Eq. 7

$$+ CDF_p \times \frac{FV_{UAp}}{UA_p} \times \frac{T_{Mean \text{ Repair}}}{T_{CR}}$$

27

28 Likewise, the change in CDF per run type failure is given by:

29

30
$$MSPI = CDF_p \times \sum_{N \text{ similar comp}} \left\{ \frac{FV_{URc}}{UR_{pc}} \times \frac{T_m}{b+T_r} \right\}$$

Eq. 8

$$+ CDF_p \times \frac{FV_{UAp}}{UA_p} \times \frac{T_{Mean \text{ Repair}}}{T_{CR}}$$

1 In these expressions, the variables are as defined earlier and additionally

2 T_{MR} is the mean time to repair for the component

3 and

4 T_{CR} is the number of critical hours in the monitoring period.

5 The summation in the equations is taken over all similar components within a system.

6 With multiple components of a given type in one system, the impact of the failure on

7 CDF is included in the increased unavailability of all components of that type due to

8 pooling the demand and failure data.

9 The mean time to repair can be estimate as one-half the Technical Specification Allowed

10 Outage Time for the component and the number of critical hours should correspond to the

11 1999 – 2001 actual number of critical hours.

12 These equations are be used for all failure modes for each component in a system. If the

13 resulting value of ΔCDF is greater than 1.0×10^{-6} for any failure mode of any component,

14 then the performance index for that system is not considered valid.

15

16 Definitions

17

18 *Train Unavailability:* Train unavailability is the ratio of the hours the train was
19 unavailable to perform its risk-significant functions due to planned or unplanned
20 maintenance or test during the previous 12 quarters while critical to the number of critical
21 hours during the previous 12 quarters. (Fault exposure hours are not included;
22 unavailable hours are counted only for the time required to recover the train's risk-
23 significant functions.)

24 *Train unavailable hours:* The hours the train was not able to perform its risk significant
25 function due to maintenance, testing, equipment modification, electively removed from
26 service, corrective maintenance, or the elapsed time between the discovery and the
27 restoration to service of an equipment failure or human error that makes the train
28 unavailable (such as a misalignment) while the reactor is critical.

29 *Fussell-Vesely (FV) Importance:*

30 The Fussell-Vesely importance for a feature (component, sub-system, train, etc.) of a
31 system is representative of the fractional contribution that feature makes to the to the total
32 risk of the system.

33 The Fussell-Vesely importance of a basic event or group of basic events that represent a
34 feature of a system is represented by:

35
$$FV = 1 - \frac{R_i}{R_0}$$

1 Where:

2 R_0 is the base (reference) case overall model risk,

3 R_i is the decreased risk level with feature i completely reliable.

4 In this expression, the second term on the right represents the fraction of the reference
 5 risk remaining assuming the feature of interest is perfect. Thus 1 minus the second term is
 6 the fraction of the reference risk attributed to the feature of interest.

7 The Fussell-Vesely importance is calculated according to the following equation:

8
$$FV = 1 - \frac{\bigcup_{j=1,n} C_{i,j}}{\bigcup_{j=1,m} C_{0,j}},$$

9 where the denominator represents the union of m minimal cutsets C_0 generated with the
 10 reference (baseline) model, and the numerator represents the union of n minimal cutsets
 11 C_i generated assuming events related to the feature are perfectly reliable, or their failure
 12 probability is False.

13 *Critical hours:* The number of hours the reactor was critical during a specified period of
 14 time.

15 *Component Unreliability:* Component unreliability is the probability that the component
 16 would not perform its risk-significant functions when called upon during the previous 12
 17 quarters.

18 *Active Component:* A component whose failure to change state renders the train incapable
 19 of performing its risk-significant functions. In addition, all pumps and diesels in the
 20 monitored systems are included as active components. (See clarifying notes.)

21 *Manual Valve:* A valve that can only be operated by a person. An MOV or AOV that is
 22 remotely operated by a person may be an active component.

23 *Start demand:* Any demand for the component to successfully start to perform its risk-
 24 significant functions, actual or test. (Exclude post maintenance tests, unless in case of a
 25 failure the cause of failure was independent of the maintenance performed.)

26 *Post maintenance tests:* Tests performed following maintenance but prior to declaring the
 27 train/component operable, consistent with Maintenance Rule implementation.

28 *Run demand:* Any demand for the component, given that it has successfully started, to
 29 run/operate for its mission time to perform its risk-significant functions. (Exclude post
 30 maintenance tests, unless in case of a failure the cause of failure was independent of the
 31 maintenance performed.)

32 *EDG failure to start:* A failure to start includes those failures up to the point the EDG has
 33 achieved rated speed and voltage. (Exclude post maintenance tests, unless the cause of
 34 failure was independent of the maintenance performed.)

1 *EDG failure to load/run:* Given that it has successfully started, a failure of the EDG
2 output breaker to close, loads successfully sequence and to run/operate for one hour to
3 perform its risk-significant functions. This failure mode is treated as a demand failure for
4 calculation purposes. (Exclude post maintenance tests, unless the cause of failure was
5 independent of the maintenance performed.)

6 *EDG failure to run:* Given that it has successfully started and loaded and run for an hour,
7 a failure of an EDG to run/operate for its mission time to perform its risk-significant
8 functions. (Exclude post maintenance tests, unless the cause of failure was independent of
9 the maintenance performed.)

10 *Pump failure on demand:* A failure to start and run for at least one hour is counted as
11 failure on demand. (Exclude post maintenance tests, unless the cause of failure was
12 independent of the maintenance performed.)

13 *Pump failure to run:* Given that it has successfully started and run for an hour, a failure of
14 a pump to run/operate for its mission time to perform its risk-significant functions.
15 (Exclude post maintenance tests, unless the cause of failure was independent of the
16 maintenance performed.)

17 *Valve failure on demand:* A failure to open or close is counted as failure on demand.
18 (Exclude post maintenance tests, unless the cause of failure was independent of the
19 maintenance performed.)

20 Clarifying Notes

21 Train Boundaries and Unavailable Hours

22 Include all components that are required to satisfy the risk-significant function of the
23 train. For example, high-pressure injection may have both an injection mode with
24 suction from the refueling water storage tank and a recirculation mode with suction from
25 the containment sump. Some components may be included in the scope of more than one
26 train. For example, one set of flow regulating valves and isolation valves in a three-pump,
27 two-steam generator system are included in the motor-driven pump train with which they
28 are electrically associated, but they are also included (along with the redundant set of
29 valves) in the turbine-driven pump train. In these instances, the effects of unavailability
30 of the valves should be reported in both affected trains. Similarly, when two trains
31 provide flow to a common header, the effect of isolation or flow regulating valve failures
32 in paths connected to the header should be considered in both trains

33 Cooling Water Support System Trains

34 The number of trains in the Cooling Water Support System will vary considerably from
35 plant to plant. The way these functions are modeled in the plant-specific PRA will
36 determine a logical approach for train determination. For example, if the PRA modeled
37 separate pump and line segments, then the number of pumps and line segments would be
38 the number of trains.

1 ~~The determination of trains for the cooling water support system may be difficult. In this~~
2 ~~case, the system should be defined in segments, and each segment treated in the~~
3 ~~calculation of UAI as if it were a train. A segment may be as small as an individual~~
4 ~~component in a system. The general approach should be to divide the system into as few~~
5 ~~segments as possible and still describe the functionality of the system. In no case should~~
6 ~~a segment be larger than a single train of a system.~~

7

8 Active Components

9 For unreliability, use the following criteria for determining those components that should
10 be monitored:

- 11 • Components that are normally running or have to change state to achieve the risk
12 significant function will be included in the performance index. Active failures of
13 check valves and manual valves are excluded from the performance index and will be
14 evaluated in the NRC inspection program.
- 15 • Redundant valves within a train are not included in the performance index. Only
16 those valves whose failure alone can fail a train will be included. The PRA success
17 criteria are to be used to identify these valves.
- 18 • Redundant valves within a multi-train system, whether in series or parallel, where the
19 failure of both valves would prevent all trains in the system from performing a risk-
20 significant function are included. (See Figure F-5)
- 21 • All pumps and diesels are included in the performance index

22 Table 3 defines the boundaries of components, and Figures F-1, F-2, F-3 and F-4 provide
23 examples of typical component boundaries as described in Table 3. Each plant will
24 determine their system boundaries, active components, and support components, and
25 have them available for NRC inspection.

26 Failures of Non-Active Components

27 Failures of SSC's that are not included in the performance index will not be counted as a
28 failure or a demand. Failures of SSC's that cause an SSC within the scope of the
29 performance index to fail will not be counted as a failure or demand. An example could
30 be a manual suction isolation valve left closed which causes a pump to fail. This would
31 not be counted as a failure of the pump. Any mispositioning of the valve that caused the
32 train to be unavailable would be counted as unavailability from the time of discovery.
33 The significance of the mispositioned valve prior to discovery would be addressed
34 through the inspection process.

35

36 Baseline Values

37 The baseline values for unreliability are contained in Table 2 and remain fixed.

1 The baseline values for unavailability include both plant-specific planned unavailability
2 values and unplanned unavailability values. The unplanned unavailability values are
3 contained in Table 1 and remain fixed. They are based on ROP PI industry data from
4 1999 through 2001. (Most baseline data used in PIs come from the 1995-1997 time
5 period. However, in this case, the 1999-2001 ROP data are preferable, because the ROP
6 data breaks out systems separately (some of the industry 1995-1997 INPO data combine
7 systems, such as HPCI and RCIC, and do not include PWR RHR). It is important to note
8 that the data for the two periods is very similar.)

9 Support cooling is based on ~~...plant specific unplanned and planned unavailability for~~
10 ~~years 1999 to 2001. Need to review support cooling pump and valve characteristics to~~
11 ~~those in Table 2 to determine if they are representative]...~~

12 The baseline planned unavailability is based on actual plant-specific values for the period
13 1999 through 2001. These values are expected to remain fixed unless the plant
14 maintenance philosophy is substantially changed with respect to on-line maintenance or
15 preventive maintenance. In these cases, the planned unavailability baseline value can be
16 adjusted. A comment should be placed in the comment field of the quarterly report to
17 identify a substantial change in planned unavailability. To determine the planned
18 unavailability:

- 19 1. Record the total train unavailable hours reported under the Reactor Oversight Process
20 for 1999 through 2001.
- 21 2. Subtract any fault exposure hours still included in the 1999-2001 period.
- 22 3. Subtract unplanned unavailable hours
- 23 4. Add any on-line overhaul hours and any other planned unavailability excluded in
24 accordance with NEI 99-02.²
- 25 5. Add any planned unavailable hours for functions monitored under MSPI which were
26 not monitored under SSU in NEI 99-02.
- 27 6. Subtract any unavailable hours reported when the reactor was not critical.
- 28 7. Subtract hours cascaded onto monitored systems by support systems.
- 29 8. Divide the hours derived from steps 1-6 above by the total critical hours during 1999-
30 2001. This is the baseline planned unavailability

31 Baseline unavailability is the sum of planned unavailability from step 7 and unplanned
32 unavailability from Table 1.

33

34

² Note: The plant-specific PRA should model significant on-line overhaul hours.

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3
4

**Table 1. Historical Unplanned Maintenance Unavailability Train Values
(Based on ROP Industrywide Data for 1999 through 2001)**

SYSTEM	UNPLANNED UNAVAILABILITY/TRAIN
EAC	1.7 E-03
PWR HPSI	6.1 E-04
PWR AFW (TD)	9.1 E-04
PWR AFW (MD)	6.9 E-04
PWR AFW (DieselD)	7.6 E-04
PWR (except CE) RHR	4.72 E-04
CE RHR	1.1 E-03
BWR HPCI	3.3 E-03
BWR HPCS	5.4 E-04
BWR RCIC	2.9 E-03
BWR RHR	1.2 E-03
Support Cooling	No Data Available

5

Table 2. Industry Priors and Parameters for Unreliability

Component	Failure Mode	a ^a	b ^a	Industry Mean Value ^b	Source(s)
Motor-operated valve	Fail to open (or close)	5.0E-1	2.4E+2	2.1E-3	NUREG/CR-5500, Vol. 4,7,8,9
Air-operated valve	Fail to open (or close)	5.0E-1	2.5E+2	2.0E-3	NUREG/CR-4550, Vol. 1
Motor-driven pump, standby	Fail to start	5.0E-1	2.4E+2	2.1E-3	NUREG/CR-5500, Vol. 1,8,9
	Fail to run	5.0E-1	5.0E+3h	1.0E-4/h	NUREG/CR-5500, Vol. 1,8,9
Motor-driven pump, running or alternating	Fail to start	4.9E-1	1.6E+2	3.0E-3	NUREG/CR-4550, Vol. 1
	Fail to run	5.0E-1	1.7E+4h	3.0E-5/h	NUREG/CR-4550, Vol. 1
Turbine-driven pump, AFWS	Fail to start	4.7E-1	2.4E+1	1.9E-2	NUREG/CR-5500, Vol. 1
	Fail to run	5.0E-1	3.1E+2	1.6E-3/h	NUREG/CR-5500, Vol. 1
Turbine-driven pump, HPCI or RCIC	Fail to start	4.6E-1	1.7E+1	2.7E-2	NUREG/CR-5500, Vol. 4,7
	Fail to run	5.0E-1	3.1E+2h	1.6E-3/h	NUREG/CR-5500, Vol. 1,4,7
Diesel-driven pump, AFWS	Fail to start	4.7E-1	2.4E+1	1.9E-2	NUREG/CR-5500, Vol. 1
	Fail to run	5.0E-1	6.3E+2h	8.0E-4/h	NUREG/CR-4550, Vol. 1
Emergency diesel generator	Fail to start	4.8E-1	4.3E+1	1.1E-2	NUREG/CR-5500, Vol. 5
	Fail to load/run	5.0E-1	2.9E+2	1.7E-3 ^c	NUREG/CR-5500, Vol. 5
	Fail to run	5.0E-1	2.2E+3h	2.3E-4/h	NUREG/CR-5500, Vol. 5

1 a. A constrained, non-informative prior is assumed. For failure to run events, $a = 0.5$ and
 2 $b = (a)/(\text{mean rate})$. For failure upon demand events, a is a function of the mean
 3 probability:

4

5	<u>Mean Probability</u>	<u>a</u>
6	0.0 to 0.0025	0.50
7	>0.0025 to 0.010	0.49
8	>0.010 to 0.016	0.48
9	>0.016 to 0.023	0.47
10	>0.023 to 0.027	0.46

11

12 Then $b = (a)(1.0 - \text{mean probability})/(\text{mean probability})$.

13

14 b. Failure to run events occurring within the first hour of operation are included within
 15 the fail to start failure mode. Failure to run events occurring after the first hour of
 16 operation are included within the fail to run failure mode. Unless otherwise noted, the
 17 mean failure probabilities and rates include the probability of non-recovery. Types of
 18 allowable recovery are outlined in the clarifying notes, under "Credit for Recovery
 19 Actions."

20

21 c. Fail to load and run for one hour was calculated from the failure to run data in the
 22 report indicated. The failure rate for 0.0 to 0.5 hour ($3.3E-3/h$) multiplied by 0.5 hour,
 23 was added to the failure rate for 0.5 to 14 hours ($2.3E-4/h$) multiplied by 0.5 hour.

Table 3. Component Boundary Definition

Component	Component boundary
Diesel Generators	The diesel generator boundary includes the generator body, generator actuator, lubrication system (local), fuel system (local), cooling components (local), startup air system receiver, exhaust and combustion air system, dedicated diesel battery (which is not part of the normal DC distribution system), individual diesel generator control system, circuit breaker for supply to safeguard buses and their associated local control circuit (coil, auxiliary contacts, wiring and control circuit contacts, and breaker closure interlocks) .
Motor-Driven Pumps	The pump boundary includes the pump body, motor/actuator, lubrication system cooling components of the pump seals, the voltage supply breaker, and its associated local control circuit (coil, auxiliary contacts, wiring and control circuit contacts).
Turbine-Driven Pumps	The turbine-driven pump boundary includes the pump body, turbine/actuator, lubrication system (including pump), extractions, turbo-pump seal, cooling components, and local turbine control system (speed).
Motor-Operated Valves	The valve boundary includes the valve body, motor/actuator, the voltage supply breaker (both motive and control power) and its associated local open/close circuit (open/close switches, auxiliary and switch contacts, and wiring and switch energization contacts).
Air-Operated Valves	The valve boundary includes the valve body, the air operator, associated solenoid-operated valve, the power supply breaker or fuse for the solenoid valve, and its associated control circuit (open/close switches and local auxiliary and switch contacts).

1

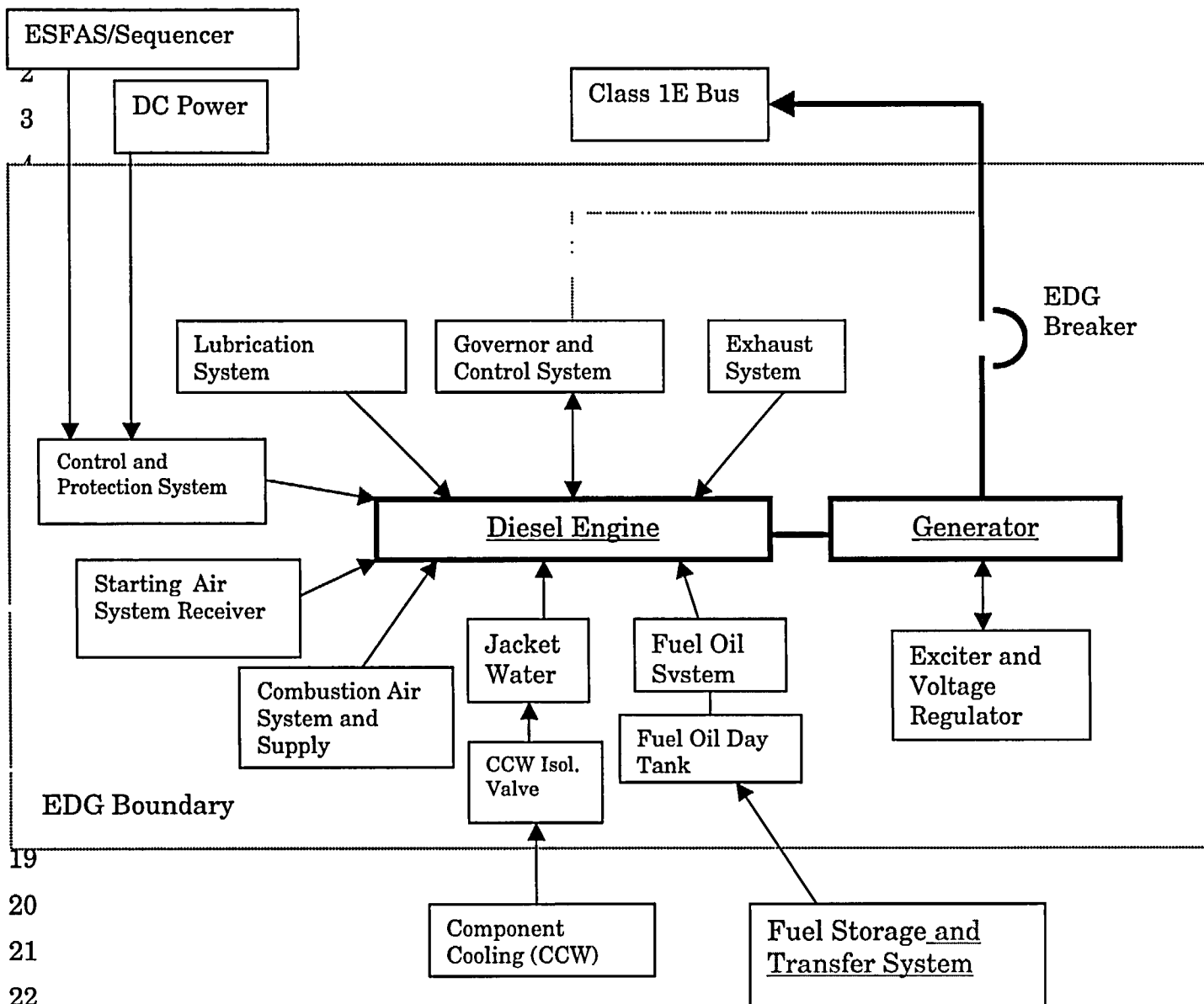
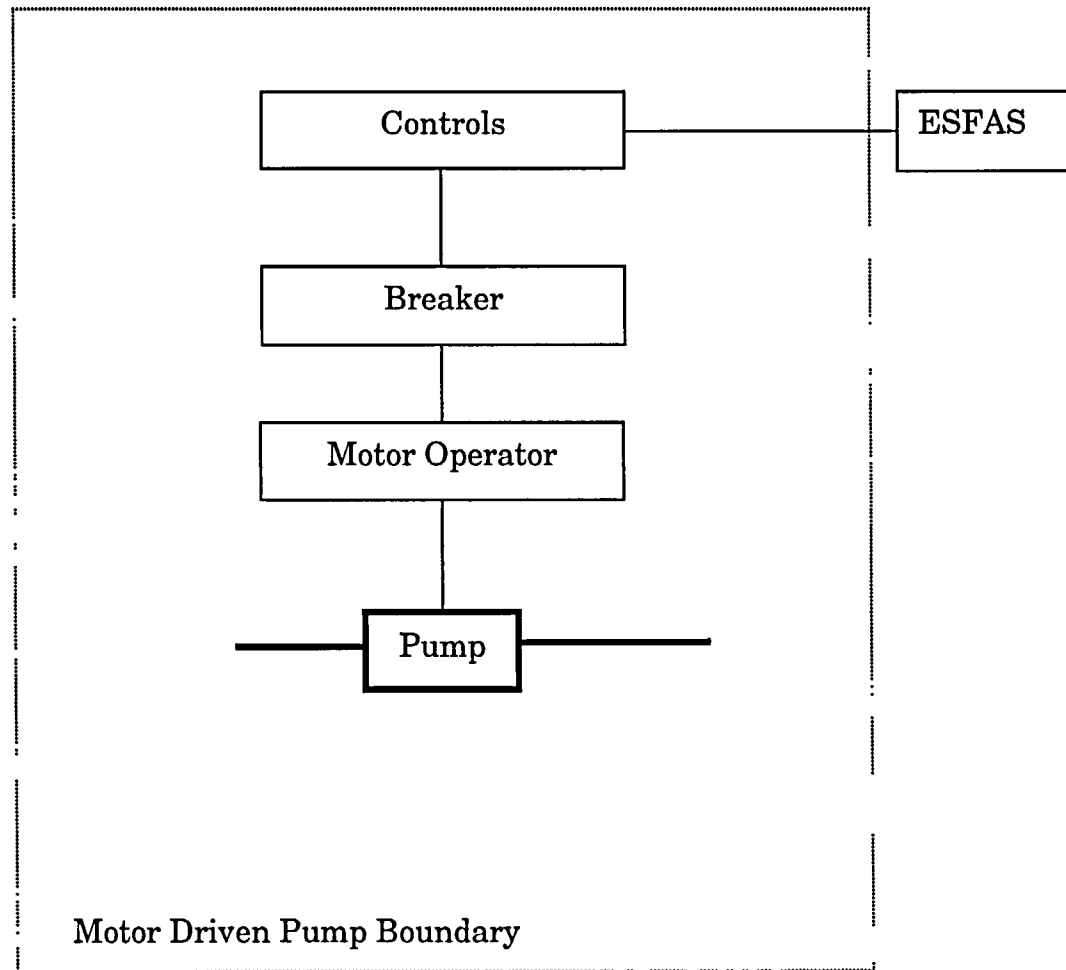


Figure F-1

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Figure F-2

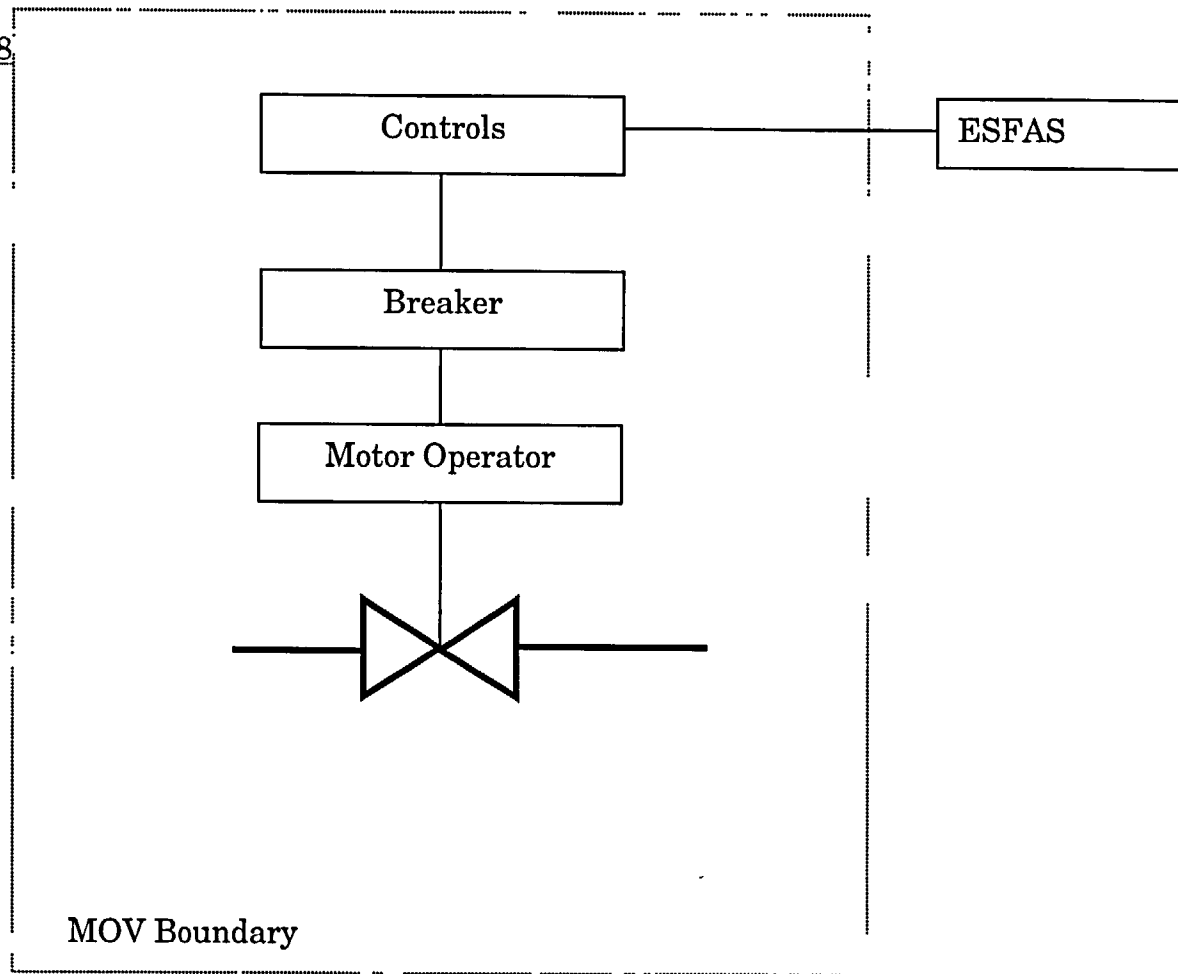
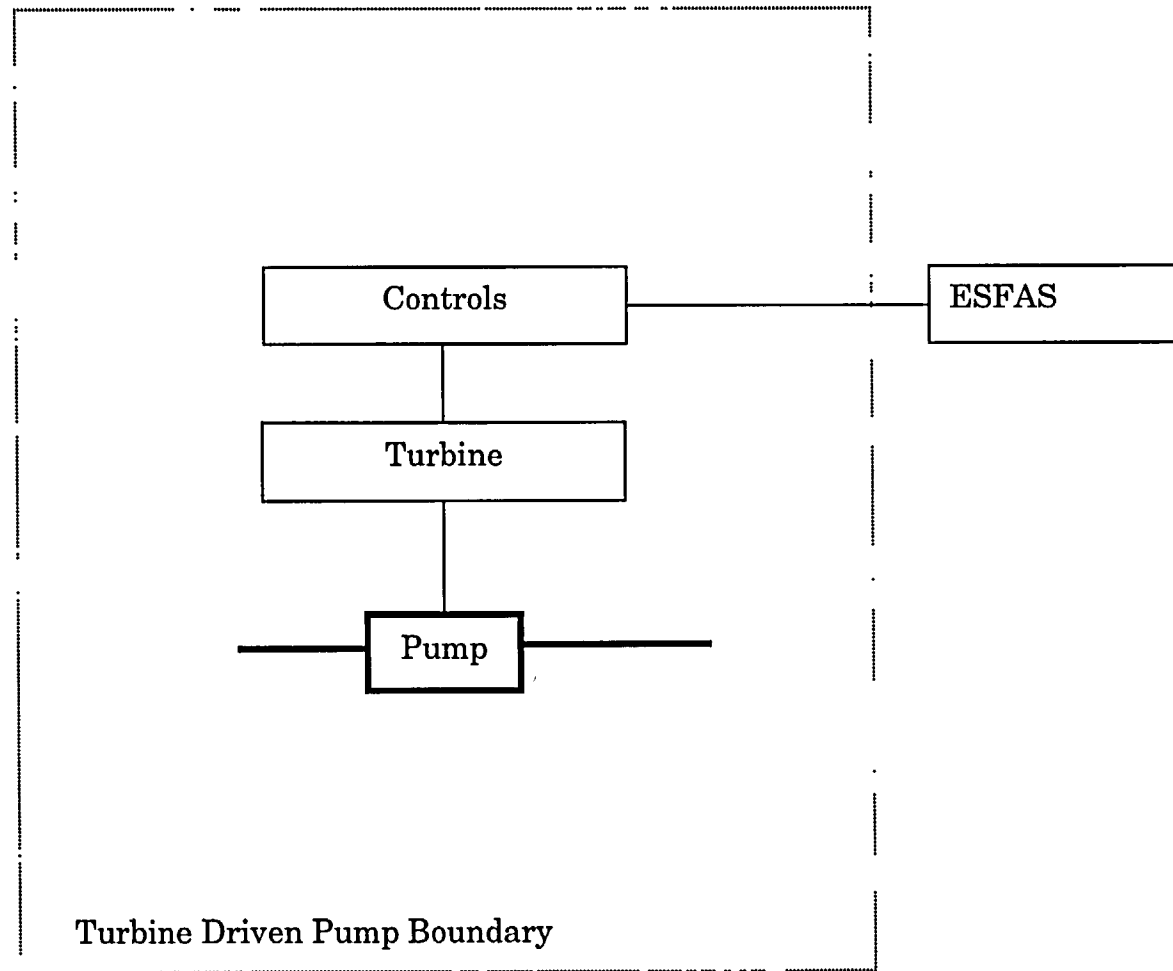


Figure F-3

1
2

1



2

3

4

Figure F-4

1

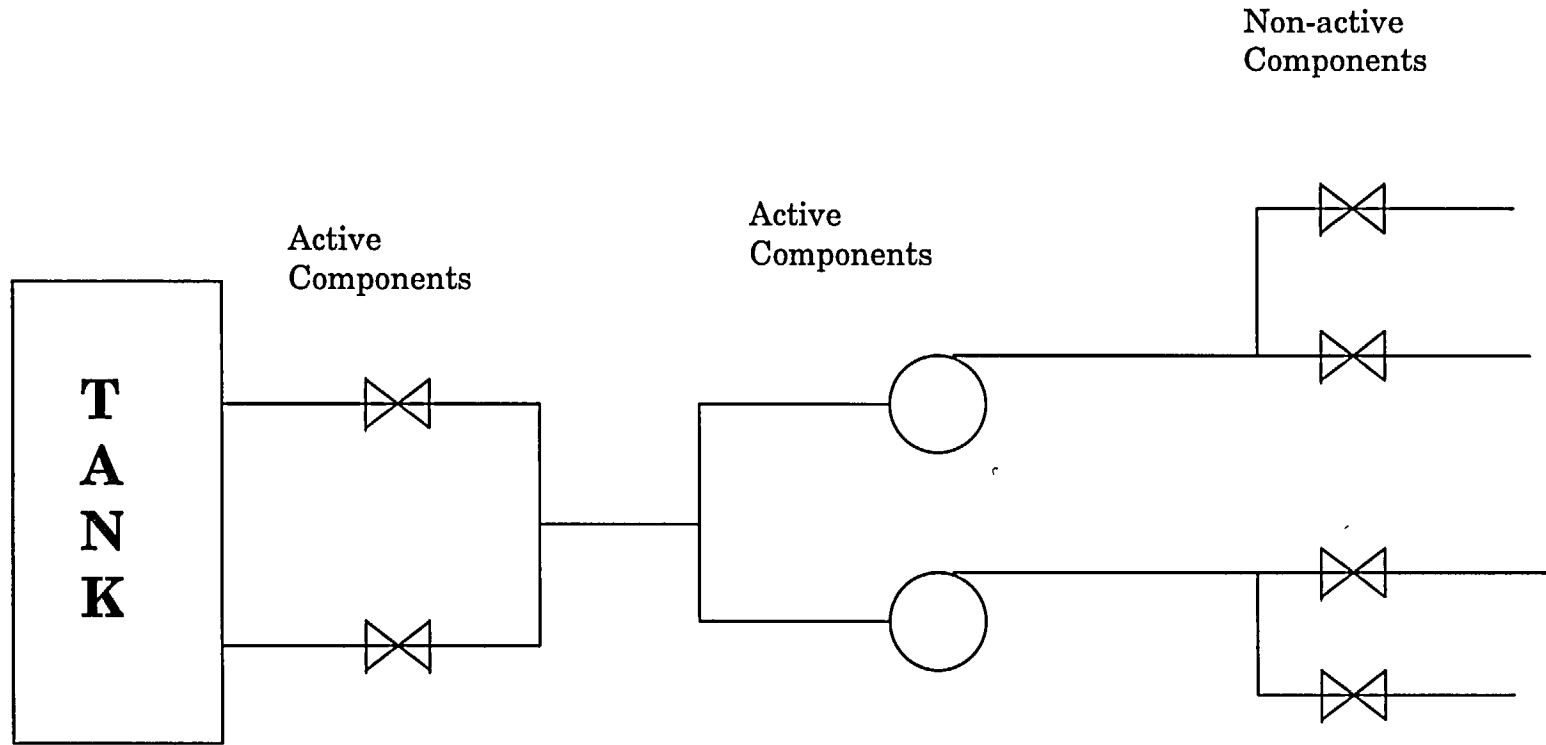


Figure F-5