FMD 2016

# FAILURE MODE MECHANISM DISTRIBUTIONS

**RELIABILITY DATABOOK SERIES**

*failure data for a wide variety of component types*

QUANTERION SOLUTIONS INCORPORATED

Ordering No.: FMD-2016

# Failure Mode/Mechanism Distributions 2016

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## Preface

This product contains field failure mode and mechanism distribution data on a variety of electrical, mechanical, and electromechanical parts and assemblies. This data can be used to assist in the performance of reliability analyses and assessments such as Failure Modes, Effects and Criticality Analysis (FMECA) and Fault Tree Analysis (FTA).

The data contained in FMD-2016 represents over 990,000 new records, a 10-times increase over the 98,000 records presented in its predecessor, FMD-2013. The CD-ROM version of FMD-2016 incorporates a user interface with search capabilities that assist in rapid data retrieval.

Data was collected for this product from a wide variety of commercial and military sources.

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## TABLE OF CONTENTS


| | | PAGE |
|---|---|---|
| SECTION 1: | BACKGROUND AND INTRODUCTION | 1-1 |
| 1.1 | Data Collection | 1-1 |
| 1.2 | Data Definitions | 1-3 |
| 1.3 | Data Interpretation | 1-7 |
| | 1.3.1 Differences Between FMD-2013 and FMD-2016 | 1-7 |
| | 1.3.2 Re-Normalizing To Remove Failure Mechanisms | 1-8 |
| | 1.3.3 Single Source Distributions | 1-8 |
| | 1.3.4 Wearout Failures | 1-8 |
| 1.4 | Data Summary Example | 1-8 |
| SECTION 2: | FAILURE DISTRIBUTION DATA | 2-1 |
| SECTION 3: | DATA SOURCES | 3-1 |
| SECTION 4: | PART DESCRIPTION INDEX | 4-1 |


## LIST OF TABLES


Table 1-1: Example of Converting Percentage Data to Quantity ..... 1-3
Table 1-2: Example of Combining Data ..... 1-6


## LIST OF FIGURES


Figure 1-1: Example Data Format ..... 1-3
Figure 1-2: Actuator Failure Distribution ..... 1-9

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# 1.0 BACKGROUND AND INTRODUCTION

The "Failure Mode/Mechanism Distributions - 2016" (FMD-2016) publication is the fourth in a series that covers Failure Mode and Mechanism Distributions on electronic, electromechanical and mechanical parts and assemblies. It updates "Failure Mode/Mechanism Distributions - 2013" and provides a cumulative compendium of failure mode/mechanism data. Knowledge of part failure trends is necessary to successfully perform many reliability analysis techniques such as a Failure Modes and Effects Analysis (FMEA). Quantification of the relative probability of occurrence for each potential failure mode (failure mode distribution) for a given part type is essential for the performance of a Failure Mode, Effects, and Criticality Analysis (FMECA).

The intent of this publication is to present failure distributions on parts and assemblies to be used in support of reliability analyses such as FMEAs and FMECAs. Data contained in this book can be used to apportion an item's failure rate into modal elements by multiplying the failure rate by the percentage attributable to specific failure modes. These distributions provide a baseline set of probabilities to be used in the reliability engineering industry. This document complements the Quanterion publication "Expanded Applications of FMECA", which provides guidance on performing FMECAs.

The scope of this publication is electrical, electronic, mechanical, and electromechanical parts and assemblies for which failure mode/mechanism data has been collected over the years. The book is organized into the following sections:

Section 1: Background on data collection, defines the data contained in Section 2, and presents a discussion allowing the user to accurately interpret the data

Section 2: Failure distribution data listings

Section 3: Data sources used in the publication

Part Index: Comprehensive cross-reference to the data contained in Section 2. Each part category has been indexed on all pertinent words contained in the part description.

## 1.1 Data Collection

The data contained in this publication was collected from a variety of sources. All sources used are briefly described in Section 3. These sources can be grouped into the following major categories:

(1) Published Information: To aid in data collection activities in support of this effort, a literature search was conducted which identified published sources presenting failure modes/failure mechanisms or failure mode distributions. Such sources include periodicals, technical reports, and data compendiums.

(2) Maintenance Data: There are several government-sponsored databases that were used in support of this publication. In these databases, a repair technician will typically

record information regarding the cause of failure at the time a maintenance action is performed. The primary disadvantage of this data type is that the failure mode/mechanism cannot be confirmed. Data of this type was only included when a reasonable degree of credibility existed in the source.

(3) Failure Analysis Reports: Quanterion continually collects and analyzes failure mode/mechanism data from a variety of failure analysis activities. The data in this category can be from failures in actual field operation or during laboratory testing. The advantage of this kind of data is that it is usually of very high quality. A disadvantage is that the data from laboratory testing, and therefore the stresses to which the part is exposed, may not be consistent with the stresses seen by the part in field use operation. Additionally, some of the data contained in this document is from Destructive Physical Analysis (DPA), in which the part may not have functionally failed but, rather, an anomaly was discovered.

Due to the number of different sources of data that were used in the preparation of this document, the user is encouraged to review the source descriptions in Section 3 of the book to gain a better understanding of the data.

Virtually all of the new data that was collected to support this update to FMD-2013 was provided in a form in which the quantities of failure were known. Less than 20% of the data in this document is percentage data only. For this reason, Quanterion has used a data merging algorithm that weighs each data source in an amount proportional to the total number of reported failures in that data source. To combine data in this manner, it is necessary to convert all data that is in percentage form to quantities. To accomplish this, the following iterative steps were taken:

1. A quantity of "1" was assigned to the lowest percentage failure mode/mechanism ($\%_1$)
2. Quantities of all other failure modes/mechanisms were calculated:

$$[(\text{Quantity of lowest percentage}) \bullet (\%_i / \%_1)]$$

   where $\%_i$ is the percentage associated with the i$^{th}$ failure mode/mechanism.

3. The percentages associated with the quantities calculated above were then calculated
4. The difference between the percentages from the original data was compared to the percentage derived from Step 3
5. If the difference of any failure mode/mechanism (between the actual and calculated) was greater than 1.0%, the quantity associated with the lowest percentage was incremented by "1" and Steps 2, 3 and 4 were repeated until all differences were less than 1.0%.

An example of this method of converting to quantities is summarized in Table 1-1.

Table 1-1: Example of Converting Percentage Data to Quantity

| Failure Mode | Percentage | Qty=1 | $\%_1$ | $\Delta\%_1$ | Qty=2 | $\%_2$ | $\Delta\%_2$ |
|---|---|---|---|---|---|---|---|
| Open | 75 | 8 | 72.7 | 2.3 | 15 | 75 | 0 |
| Short | 15 | 2 | 18.2 | 2.8 | 3 | 15 | 0 |
| Drift | 10 | 1 | 9.1 | .9 | 2 | 10 | 0 |

In this particular example, the lowest quantity resulting in errors of less than 1% is a total of 20, of which a quantity of "2" is associated with the lowest percentage failure mode. After this step, all of the data is in the common unit of "number of observances". The data from all data sources can now be combined by summing the quantities associated with each failure mode/mechanism from each data source and converting the quantities to percentages (i.e., quantity of the specific failure mode/mechanism divided by the total quantity).

## 1.2 Data Definitions

The list below defines the headings contained in the Failure Distribution Data Listing pages. Discussion in this subsection presents information that allows the user to better understand and interpret the data presented in Section 2. The Section 2 table headings are as follows:

- Part Description
- Failure Mode/Mechanism
- Normalized Distribution (Norm Dist)
- Failure Distribution (Fail Dist)
- Data Details
- Data Source
- Quantity (Percentage)

Each of these items is defined and discussed further in the following paragraphs to give a better understanding of how the data was categorized and summarized.

Figure 1-1 provides an example of "Actuator" from Section 2, with the associated header fields.

| **Part Description**<br>Failure Mode/Mechanism | Norm Dist | Fail Dist | Data Details | Source | Quantity(%) |
|---|---|---|---|---|---|
| **Actuator** | | | | 6 Sources | |
| Spurious Position Change | 43.8% | 21.2% | Catastrophic-Spurious Position Change | 18175-000 | 7( 70.0%) |
| Worn | 18.8% | 9.1% | Excessive Wear | 28565-000 | 2 |
| | | | Worn Excess | 28565-000 | 1 |
| Aged/Deteriorated | 12.5% | 6.1% | Deteriorated/Aged, Seized | 25101-000 | 1 |
| | | | Requires Overhaul | 19542-000 | 1( 6.7%) |
| Cable Failure | 12.5% | 6.1% | Cable Insulation Frayed | 19542-000 | 1( 6.7%) |
| | | | Cable Sleeve Needs Fixing | 19542-000 | 1( 6.7%) |
| Ripped Boot | 12.5% | 6.1% | Boot Rip Failures, Mechanical Strain | 23052-000 | 2 |
| Unknown | ----- | 18.2% | Unknown | 19542-000 | 6( 39.7%) |
| Induced | ----- | 12.1% | Degraded, Premature Or Delayed Actuation | 18175-000 | 3( 30.0%) |
| | | | Safety Wire Bracket Broken | 19542-000 | 1( 6.7%) |
| Workmanship | ----- | 6.1% | Improper Configuration Should Be -2 | 19542-000 | 1( 6.7%) |
| | | | Improper Connector Installed | 19542-000 | 1( 6.7%) |
| Other | ----- | 15.0% | | | |
| Bearing or Brake Failure | | 3.0% | Bearing & Brake Rusted | 19542-000 | 1( 6.7%) |
| Diagnostic Failure | | 3.0% | Diagnostic | 28565-000 | 1 |
| Inoperative | | 3.0% | Inoperative | 28565-000 | 1 |
| Out of Adjustment | | 3.0% | Requires Adjustment Of TM | 19542-000 | 1( 6.7%) |
| Switch Failure | | 3.0% | Thermal Switch Found To Be Defective | 19542-000 | 1( 6.7%) |
| Jammed/Stuck | | N/R | Jamming-Contamination | 25036-000 | N/R |
| No Output | | N/R | No Output-Contamination | 25036-000 | N/R |
| Reduced Output | | N/R | Reduction In Output Force Or Stroke | 25036-000 | N/R |

Figure 1-1: Example Data Format

## PART DESCRIPTION

The Part Description is presented at levels of classification which are separated by commas. The first level is used to describe the generic function/description of the part and the remaining levels are used as more detailed descriptions of the part. In the example of Figure 1-1, “Actuator” data is presented. In this case, there is no further description provided of the specific actuator type. For Integrated Circuits (IC's), the second level is always the Package Material and the last level is always the Technology Type. The term "Unknown" in either of these fields indicates insufficient data to accurately describe the part at that level.

Each failure mode/mechanism distribution contained in this book was extracted from one or more individual data sources. In cases where more than one source was utilized, the data was combined into a single listing of failure modes/mechanisms for each part type. The manner in which this combining occurred is presented in Section 1.4 "Data Summary Example". Since there can be several sources combined to derive a single distribution, the manner in which parts are defined must be consistent between sources. Since these descriptions, as they were collected, varied significantly for a given generic part type, they were made consistent to ensure commonality in part descriptions between sources, so that data could be combined on similar part types in a consistent manner. Part descriptions were only changed when necessary. In all cases, the intent and meaning of the original data source was preserved.

To obtain failure distributions for a generic family of part types, data merges were performed on the selected types. For example, the summary for "Attenuators" is a merge of all attenuator data, regardless of specific type (i.e., fixed, variable, etc.). These summaries are contained in Section 2 and are denoted with the word ("Summary") next to the part description. For these entries, only the normalized failure distribution is presented.

Some items may have failures listed that are not applicable to its generic category but, rather, are applicable to the specific part from which the data was collected. For this reason, the user is cautioned to use the "Summary" data entries judiciously. If it is known that a failure mode is not applicable for a particular part, the data can be re-normalized by excluding the percentage associated with that failure mode.

## FAILURE MODE/MECHANISM

The Failure Mode/Mechanism field presents the categorized failure modes or mechanisms. For the purposes of this publication:

- A failure mode is defined as the observable consequence of failure
- A failure mechanism is defined as the physical process which causes the failure

This column represents the failure modes/mechanisms as they were categorized by Quanterion from the detailed failure description (presented in the Data Details column). During this classification process, Quanterion reviewed all failure modes and mechanisms for a given part type and structured a generic list representative of all data sources.

Failure mode and mechanism information has been collected from many different sources, with each source generally having its own unique way of reporting this information. In some cases, failure modes of assemblies were presented as constituent part failures of the assembly that failed. In other cases, the actual failure mode/mechanism of the assembly was presented. There are cases in which the failure mode/mechanism classification may appear to be inconsistent, since there may be two sources of data for a particular part, one presenting constituent part failure modes/mechanisms and the other actual failure modes/mechanisms of the assembly. However, in cases where the failure modes/mechanisms listed are a combination of consequences of failure and of constituent part failure, the user can tailor this data to his particular needs by converting one to the other. An example of this approach is "Transformers", in which one case a failure mode listed may be "Shorted", whereas another may be "Insulation Failure". "Short" is an observable mode of failure and the "Insulation Failure" is the site or constituent component of failure. In this case, the user can discard the "Insulation Failure" mode and re-normalize the distribution or, if there is enough confidence that the "Insulation Failure" resulted in a "Short", the two percentages can be combined under "Short". In any case, this would have to be accomplished based on a knowledge of the physical properties of the part/assembly and its related reliability issues. Quanterion has attempted to make these listings consistent, where possible. However, in some cases, these two different types of failure modes are presented to allow the user flexibility in tailoring the distributions to his particular needs.

Additionally, some of the presented failure modes/mechanisms may be redundant. For example, one failure mode/mechanism may lead to another failure mode/mechanism (e.g., "Corrosion" can lead to "Sticking/Binding"). Also, there may be failure modes/mechanisms with the same meaning (e.g., Shorted/No Operation). In general, Quanterion has reported data as it was reported by the original data source. If the user wishes to merge these failure modes/mechanisms, it can be accomplished by combining the quantities associated with the failure modes/mechanisms to be combined, then re-calculating the associated percentages.

It should be noted that all failure distributions listed will not be applicable to all situations. This is because the data comprising these distributions was collected from a variety of component types, quality levels, and environments. Therefore, the summary distributions represent observed averages and the actual distributions will vary, depending on specific conditions. Also, failure distributions presented are dependent, in part, upon the specific use conditions of the part/assembly. In these cases, the failure mechanisms are often induced and are not inherent failure mechanisms for the device. In these instances, the failure distributions may have limited applicability to the "generic" family of part/assembly types, and are merely presented to illustrate how such devices have failed in the past.

## NORMALIZED DISTRIBUTION (Norm Dist)

The Normalized Distribution is the Failure Distribution (discussed in the next section) excluding the categories "Other", "Unknown", "Induced", and "Workmanship". The category "Other" is defined and further discussed in the "Data Summary Example" of Section 1.4.

Additionally, for some part types it may be preferable to normalize out the wearout failure causes when deriving modal failure rates for the performance of FMECAs. This is especially important if the source of failure rate data used does not include wearout failures.

Many of the data sources used to derive failure classifications were from field maintenance activities. As a result, many non-inherent or "induced" failures are included in the data. In the context of this data, induced failures are considered to be non-inherent failures resulting from part misapplication, overstress, etc. Quanterion then reviewed this data to ensure that failure classifications were logical. The Normalized Distribution excludes non-inherent failures.

## FAILURE DISTRIBUTION (Fail Dist)

The Failure Distribution (Fail Dist) Column represents the distribution of all categorized failure modes/mechanisms from all data sources for a particular part type. This distribution is representative of all categorized failure types, including "Other", "Unknown", "Induced", and "Workmanship". When possible, maintenance records that contained replacement of non-failed parts were discarded from the database. This distribution was derived in the following manner:

1) Sources with percentages of parts failing in a particular manner were converted to a quantity using the methodology described previously in Section 1.1.
2) These quantities were merged with the quantities of other sources.

As an example, consider the example in Table 1-2.

Table 1-2: Example of Combining Data

| Failure Mode | Source 1 Percentage (Qty) | Source 2 Quantity | Source 3 Quantity | Total Quantity | Merged Percentage |
|---|---|---|---|---|---|
| **Failure Mode 1** | 75% (15) | 8 | 2 | 25 | 65.8% |
| **Failure Mode 2** | 15% (3) | 5 | 3 | 11 | 28.9% |
| **Failure Mode 3** | 10% (2) | 2 | 1 | 2 | 5.3% |

In this hypothetical example, Source 1 provided the failure distribution in percentages and had to be converted to quantities. This was accomplished using the methodology previously presented. The quantities used in subsequent data merging is shown in parenthesis. Sources 2 and 3 provided the quantities of each failure mode. Once the percentages of Source 1 are converted to quantities, the quantities associated with all three sources can be added (Total Quantity) and these quantities can be converted to percentages.

Where the term "N/R" (meaning "Not Reported") appears in this column, a failure event was identified by the source, but no percentage or quantity was given. This information is provided so that the user can identify applicable failure modes, even though percentages associated with those modes cannot be determined.

**DATA DETAILS**

The Data Details column presents the detailed failure descriptions exactly as they were reported to Quanterion from each listed data source. The detailed data is presented to give the user an understanding of the failures as they were reported, and to present the actual quantity or percentage of each specific failure by source. Each categorized Failure Mode/Mechanism can have many associated detailed failure modes/mechanisms.

Combining data in the manner previously described results in "average" failure mode distributions. While these distributions are intended to be used as baseline or default values (particularly in the absence of other data), actual distributions can vary significantly as a function of many variables. Some of these variables include device maturity, time during the life cycle (early life, or wearout periods), application environment, device quality, and manufacturing process.

**DATA SOURCE**

Each Data Source that Quanterion used in the compilation of data for FMD-2016 is identified by a unique number that is presented in the Data Source column. Each source is uniquely identified with a five-digit number, followed by a three-digit number (e.g., 24417-000). Section 3 of the book presents a brief description of each data source record. The user of this publication is encouraged to review these source descriptions in order to obtain a better understanding of the data.

For each Part Description, the number of unique data sources used in the derivation of the failure distribution is presented. For example, if "3 Sources" appears in the Data Source column at the top of the entries for a given part type, there were three unique sources of data that Quanterion had for that part type, so there are three unique source numbers.

**QUANTITY**

This field represents the total number of parts failing in the manner described by the "Data Detail" column. If there is only a numeric quantity presented in this field, then the source of that data reported those specific quantities of parts. If, however, there is a number followed by a percentage in parentheses, then the original source reported its data to Quanterion in percentages (shown in parenthesis) and the specific quantity was not known. The numeric quantity indicated was derived using the methodology previously described.

## 1.3 Data Interpretation

### 1.3.1 Differences Between FMD-2013 and FMD-2016

FMD-2016 is a cumulative compendium of failure mode and mechanism data. All data that was contained in FMD-2013 is contained in this update, along with new data that has been collected by Quanterion since FMD-2013 was published.

Note that there may be failure mode/mechanism distribution percentages that are different between FMD-2016 and FMD-2013, even though no new data may have been added. This may have happened as a result of the generic failure modes assigned to the detailed data being re-examined and, in some cases, changed to be more consistent.

### 1.3.2 Re-Normalizing To Remove Failure Mechanisms

The data in this book contains a mix of both failure mode and failure mechanism data for individual part types. In cases where a failure mode resulting from a specific failure mechanism was clear, the mechanism was categorized accordingly. In cases where the resulting failure mode was not known, the mechanism was kept separate and included with the modes. If a true failure mode distribution (without mechanisms) is needed in support of an analysis such as a FMECA, then the unwanted entries in the distribution can be eliminated by deleting those entries and re-normalizing the distribution. This can be accomplished by considering the quantities associated with the desired failure modes and re-calculating the distributions, such that the sum of the percentages is 100%.

### 1.3.3 Single Source Distributions

In many cases, there is only one source of data for a particular part type. For these cases, the resulting distribution is entirely dependent on a single data source and may not adequately represent industry averages. Although there is typically limited data to quantify an accurate average failure distribution, the data should identify the predominant failure trends for that part type. Additionally, the user of this data is encouraged to utilize the distribution for more generic part types, when available, in the event that there is insufficient data to form a meaningful distribution for a specific part type.

### 1.3.4 Wearout Failures

Wearout failures, by their very nature, occur in the entire population of parts and, therefore, can represent a very high percentage of all observable failures. Because of this, some distributions may appear to be heavily weighted towards wearout failures. The degree to which wearout failures predominate is a function of the time period over which the data was collected and whether preventive maintenance (or replacement) was performed on the item. Since the time period (relative to the life cycle of the part) over which this data was collected is typically not known, and because failure distributions can change over time, the distributions presented herein represent an average over a typical usage time interval. This is especially true when several data sources are combined. If there is only a single data source, the distribution will be representative of the specific conditions for that one data source.

## 1.4 Data Summary Example

As an example to illustrate the manner in which FMD data was summarized and combined, consider the entry for "Actuators" shown in Figure 1-2.

| | | | | | |
|---|---|---|---|---|---|
| **Actuator** | | | | 9 Sources | |
| Seal Failure | 54.5% | 40.3% | Other,Leaks And Seal Failure | 24996-000 | 48( 72.0%) |
| False Position Change | 18.2% | 13.4% | False Operation,Catastrophic-Spurious Position Change | 18175-000 | 9( 65.0%) |
| | | | False Operation,Catastrophic-Spurious Position Change | | 7( 70.0%) |
| Degraded Operation | 10.2% | 7.6% | Degraded Operation | 19542-000 | 1( 7.0%) |
| | | | Degraded Operation,Premature Or Delayed Actuation | 18175-000 | 5( 35.0%) |
| | | | Degraded Operation,Premature Or Delayed Actuation | | 3( 30.0%) |
| Body/Head Joint Failure | 8.0% | 5.9% | Mechanical Failure,Failure Of Body/Head Joint | 24996-000 | 7( 10.0%) |
| Mechanical Failure | 4.5% | 3.4% | Mechanical Failure,Corrosion; Bearing & Brake Rusted | 19542-000 | 1( 7.0%) |
| | | | Mechanical Failure,Failure And Piston Rod | 24996-000 | 3( 5.0%) |
| Worn | 4.5% | 3.4% | Worn,Excessive Wear | 28565-000 | 2 |
| | | | Worn,Worn Excess | 28565-000 | 1 |
| | | | Worn,Worn Excess | | 1 |
| Unknown | ------ | 11.8% | Other,Loose | 28565-000 | 1 |
| | | | Unknown | 19542-000 | 6( 40.0%) |
| | | | Unknown | 24996-000 | 7( 10.0%) |
| Workmanship | ------ | 1.7% | Workmanship | 19542-000 | 1( 7.0%) |
| | | | Workmanship,Improper Configuration Should Be -2 | 19542-000 | 1( 7.0%) |
| Induced | ------ | 0.8% | Mechanical Failure,Safety Wire Bracket Broken | 19542-000 | 1( 7.0%) |
| Other | ------ | 11.7% | | | |
| Aged/Deteriorated | | 1.7% | Other,Requires Overhaul | 19542-000 | 1( 7.0%) |
| | | | Worn,Deteriorated/Aged, Seized | 27006-000 | 1 |
| Cable Failure | | 1.7% | Mechanical Failure,Cable Insulation Frayed | 19542-000 | 1( 7.0%) |
| | | | Other,Cable Sleeve Needs Fixing | 19542-000 | 1( 7.0%) |
| Cylinder Body Failure | | 1.7% | Mechanical Failure,Failure Of Cylinder Body | 24996-000 | 2( 3.0%) |
| Out of Specification | | 1.7% | Out of Specification | 24992-000 | 1( 50.0%) |
| | | | Out of Specification,Excessive Start Voltage; Electrically Insulated Copper Oxide Film | 23052-000 | 1 |
| Diagnostic Failure | | 0.8% | Other,Diagnostic | 28565-000 | 1 |
| Failed To Operate | | 0.8% | Failed To Operate | 264592-000 | 1 |
| Inoperative | | 0.8% | Inoperative,Failed To Operate | 264592-000 | 1 |
| No Operation | | 0.8% | No Operation | 28565-000 | 1 |
| Seized | | 0.8% | No Operation,Stopped | 24992-000 | 1( 50.0%) |
| Switch Failure | | 0.8% | Vendor Defect,Thermal Switch Found To Be Defective | 19542-000 | 1( 7.0%) |
| Jammed/Stuck | | N/R | Mechanical Failure,Contamination | 25036-000 | N/R |
| | | | No Operation,Contamination | 25036-000 | N/R |
| Reduced Output | | N/R | Degraded Operation,Reduction In Output Force Or Stroke | 25036-000 | N/R |

Figure 1-2: Actuator Failure Distribution

In this example, there were nine (9) individual data sources which contained failure information on "Actuators". This data is representative of sources which did not contain a further breakdown of specific actuator types. If there was a more detailed description of the actuator type available to Quanterion at the time the data was summarized, there would be a comma after the term "Actuator", followed by the more detailed descriptive terms. The "Data Details" column describes the actual failure description as it was reported to Quanterion.

The first entry lists "Seal Failure" from source 24996-000, Quantity 48 (72%). This indicates that Source 24996-000 (described in Section 3) contained 48 parts that failed in the mode "Seal Failure". In this particular case, the data was reported as a percentage (72%) and was subsequently translated to a quantity (48). The term "Other, Leaks and Seal Failures" listed under Failure Mode/Mechanism is the term that Quanterion assigned to the general category of failure description after reviewing the reported failures.

The normalized failure distribution (Norm Dist) was calculated by determining the predominant inherent failure classifications of the part. This was accomplished first by ignoring the data associated with the "Unknown", "Induced", "Workmanship", and "Other" categories. To calculate the normalized percentage, all failure occurrences below a given percentage were discarded, while ensuring that no more than 7 inherent failure classes appear under the normalized percentage. For example, if by ignoring failure classes occurring less than 1% of the time, less than 7 remain, 1% is used as the cut-off, above which failure mode/mechanisms were included in the normalized percentage. If 7 or more remain, the cut-off percentage was increased in increments of 1% until 7 or fewer remained. The threshold quantity of 7 was selected because consideration of greater than 7 failure modes is impractical in the performance of FMECAs. If 7 or less failure classes exist initially, then all were included. Failures that are below the cut-off percentage are listed under the generic category "Other". In the example above, 3% was selected as the cutoff because, with the modes/mechanisms comprising 3% of the failures, there would be 10 failure modes/mechanisms comprising the normalized distribution. Without them, there are 5.

By excluding the "Induced", "Unknown", "Workmanship", and "Other" failure entries, the normalized distribution can be derived. The normalized failure distribution was then calculated (following the previously described procedure) using only the reduced set of failure classes. In this example, "Spurious Position Change", "Worn", "Aged/Deteriorated", "Cable Failure" and "Ripped Boot" comprise the normalized failure distribution. If the user requires more detail than that provided in the normalized distribution, the detailed failure distribution and specific source details of Section 3 can be consulted.

The failure distribution (Fail Dist) percentages listed are the percentages associated with all failure modes/mechanisms. The sum of the failure modes/mechanisms listed under the "Other" category is displayed on the line for "Other". In this example, there were 5 failure modes/mechanisms, 3% each that comprise the failure modes/mechanisms under the "Other" category, for a total of 15%.

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