

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Transmission Availability Data System Automatic Outage Metrics and Data

NERC – 2009 Report

June 14, 2010

to ensure
the reliability of the
bulk power system

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1 Introduction

1.1 Contributors and Acknowledgements

The North American Electric Reliability Corporation (NERC) gratefully acknowledges the support of the Transmission Availability Data System Working Group (TADSWG), Open Access Technologies International (OATI), and in 2009 the 192 reporting Transmission Owners (TOs) in NERC. The 2009 “Reporting TOs” are TOs that own any TADS facilities, as described in Section 1.3 below, as of January 1, 2009.

- TADS Phase I participation is mandatory for all U.S. TOs on the NERC Compliance Registry, and all of the NERC TOs complied.¹
- Participation is voluntary for Mexican and Canadian TOs on the NERC Compliance Registry, and all non-U.S. TOs in NERC except one voluntarily provided data.

In addition to TOs, TADS Regional Entity coordinators (RECs) in NERC, and NERC TADS administrators supported the effort.

1.2 TADS History

The TADS effort began with the establishment of a task force (TADSTF) under the direction of NERC Planning Committee in October 2006. On October 27, 2007, the NERC Board of Trustees approved the collection of TADS Phase I data beginning in calendar year 2008. Phase I covers Automatic Outage data (and the reader is referred to Appendix 1 for the definition of capitalized Phase I terms).

Subsequently, on October 29, 2008, the NERC Board approved the collection of Non-Automatic Outage data that will begin in calendar year 2010 (Phase II). On July 1, 2009 the TADSTF was converted to the TADSWG by the NERC Planning Committee.

1.3 Scope

This report covers Phase I Automatic Outage data². The 2009 Report is based upon 2009 calendar year data submitted by Transmission Owners by March 1, 2010.

Phase I TADS includes Momentary and Sustained Automatic Outages of the following Elements:

- AC Circuits ≥ 200 kV (Overhead and Underground Circuits). Radial circuits are included;
- DC Circuits with $\geq +/-200$ kV DC voltage;
- Transformers with ≥ 200 kV low-side voltage; and
- AC/DC Back-to-Back (BTB) Converters with ≥ 200 kV AC voltage, both sides.

¹ For TADS, three U.S. companies in NERC that operate multiple NERC-registered TOs were allowed to submit one TADS set of data for their combined TOs. See *NERC ID Exceptions for TADS Data* posted at [NERC ID Exceptions](#).

² Phase II data will be reported next year.

The following basic information is collected:

- Automatic Outage Data:
 - Event ID & Event Type
 - Outage ID code
 - Fault Type
 - Outage Initiation Code
 - Outage Start Time
 - Outage Duration
 - Outage Cause Codes
 - Initiating
 - Sustained
 - Outage Mode
- Element Inventory Summary:
 - Number of Elements
 - For AC and DC Circuits, Circuit Miles
 - For AC and DC Circuits, AC and DC Multi-Circuit Structure Miles.

1.4 TADS Reports – NERC, Regional, and Transmission Owner

For calendar year 2009, one NERC-wide report and eight regional reports have been produced, using a common format, and these reports are posted on the TADSWG page on the NERC Web site. The definitions are a separate document that may be downloaded at [http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_\(All\).pdf](http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_(All).pdf).

These definitions were posted on September 11, 2008 for use during calendar year 2009 data collection.

In addition, each report has an associated Excel workbook that contains non-confidential data from webTADS as well as all of the associated tables and figures in the report that were developed from that data. Those workbooks are posted on the TADS Web site along with each report.

The purpose of this report is to provide the results of the annual 2009 data collection. Moving forward the TADSWG and other NERC groups may separately provide observations, interpretations of the annual results, and suggest further areas for study. It is recommended that readers of this report not draw conclusions based on the 2008 and 2009 calendar year data collection as it will take a number of years of data to provide interpretations with a high degree of confidence.

1.5 Confidential Data Not Publicly Reported

Per the data confidentiality policy, the report does not display performance data associated with a TADS Element in a Voltage Class or for circuits of a particular construction type (Overhead or Underground) if all of the Elements in that Voltage Class and applicable construction type are reported by one TO.³ In this report, confidential performance data has *not* been displayed for the following Elements, Voltage Classes, and construction types that are reported by one TO in NERC:

³ NERC will ask the impacted TOs for permission beginning with the calendar year 2010 report.

1. AC Circuits – one TO reported all of the Underground 400-599 kV AC Circuit Performance Data in NERC. Therefore, no Underground 400-599 kV AC Circuit performance data is displayed in this report.
2. DC Circuits – one TO reported all the 200-299 kV DC Circuit performance data in NERC. In addition, one TO reported all of the Underground 400-499 kV and 500-599 kV DC Circuit performance data in NERC. Therefore, no 200-299 kV DC Circuit performance data or Underground 400-499 kV and 500-599 kV DC Circuit performance data is displayed in this report.

Where Underground circuit performance data for the above voltage classes have been excluded, that data is also excluded from the combined total (Overhead plus Underground) performance data.

1.6 Report Organization

Section 2 has summary NERC metrics and data for each of the reported Elements while Section 3 has more detailed data for these same Elements, with separate subsections devoted to each Element (e.g., Section 3.1 for AC Circuits, Section 3.3 for Transformers, etc.).

1.6.1 Table and Figure Labeling

Table NERC 1-1 shows the assigned numbering scheme for the tables and figures in this report. The prefix “NERC” indicates the region covered by the report. The table and figure numbering scheme includes the major report section heading (e.g., Section 1, 2, 3.1, etc.) followed by a “dash” and then followed by a number (e.g., 1, 2, 3, etc.) that reflects the order that the table or figure appear in the report. Any tables or figures that are purposely omitted in this report are highlighted in the Table NERC 1-1. Tables or figures may be omitted because (i) they have no data because there are no Elements, or (ii) they contain confidential TO data, or (iii) there were no reported outages.

1.6.2 Tables and Figures Data Categories

The working group elected to use a common NERC-wide template for each of the tables and figures displaying performance data. The template only includes data categories (i.e., Voltage Class and construction type) for Elements that are found within NERC. The use of a common NERC-wide template allows for all reports (regional and NERC) to utilize a familiar format while making production easier. Table NERC 1-2 shows the categories included in the NERC template.

Performance data are not shown in Tables NERC 2-1 and NERC 2-2. These tables show, respectively, the Inventory of AC equipment and DC equipment within NERC. The working group felt that a complete snapshot of all TADS categories was needed, including categories with zero inventories in NERC.

1.6.3 Tables and Figures Data Display Conventions

Some regions do not have any Elements in a Voltage Class, but since those Elements exist elsewhere within NERC, the NERC template has a row or column for them. For example, only one region in NERC has DC Circuits in the 200-299 kV Voltage Class. That Voltage Class is contained in all DC Circuit tables in the NERC and all regional

reports because the template is NERC-wide. However, the working group took these steps to assist the reader in viewing such tables:

1. Appendix 2 contains the metric definitions along with their acronyms. These acronyms are used frequently in tables and figures.
2. If there are no Elements of a particular Voltage Class and applicable construction type in a region, performance data in a table such as the number of Sustained Outages is shown as a “dash” and not a zero. Also, all calculations that would normally use that data are shown as a “dash.”
3. If there are Elements in a Voltage Class and applicable construction type, but the performance data displayed for that Element is equal to zero (for example, the number of Sustained Outages is equal to zero), a “0” is shown. In this case, if a computation using that data would result in a division by zero, a “tilde” (~) is shown for the results of that computation. This avoids the Excel “#DIV/0!” display.
4. If there are Elements in a Voltage Class and applicable construction type, but the performance data may not be displayed because it is confidential, all performance data for that Voltage Class and applicable construction type is removed and a “C” is displayed for that data. However, as explained in Section 2-3, Table NERC 2-3 (Event Types and Outages) generally includes all outage data because it does not reveal any confidential data; however, if it would reveal confidential performance data, that data would have a “C” displayed.
5. In each report subsection devoted to a specific Element (e.g., Section 3.1 for AC Circuits), separate tables display total (a) Element-Initiated Outages and (b) Other than Element-Initiated Outages for Sustained Outages by Voltage Class, and similar tables display the this data for Momentary Outages. These tables also compute metrics on a per Element basis, such as SOF. As described above, confidential performance data for a specific Voltage Class is displayed as a “C.” However, since these tables also compute per Element metrics for “All Voltages,” the “All Voltages” calculations would be incorrect if confidential performance data in a Voltage Class are excluded while non-confidential associated inventory data are included. Therefore, an “NC” has been displayed in the inventory data to ensure the correctness of the computations.⁴
6. If a cell is not supposed to contain data, a grayed pattern is inserted in that cell. For example, Circuit Miles are not applicable to Transformers.

1.7 Feedback and Comments

Readers may submit comments and feedback to tadscomments@nerc.net at any time. At present, NERC is interested in report content suggestions, such as (i) the way the report is organized (ii) the way data are displayed and (iii) the type of data that should be reported. If changes are requested, please describe the benefits of each suggested change. NERC will use this feedback to develop and improve future reports.

⁴ The Excel “SUM” function treats text such as “C” or “NC” as a zero.

Table NERC 1-1
TADS Report Tables and Figure Guide – NERC Report

Tables omitted because they have no data, contain confidential TO data, or have no reported outages are shaded as follows:

Section No. and Name	Table Title	Table No.	Figure No.
1. Introduction	TADS Report Tables and Figures Guide	NERC 1-1	
	Categories Displayed in Report Tables and Figures with Performance Data	NERC 1-2	
2. Summary NERC Metrics and Data	Inventory of AC Transmission Equipment	NERC 2-1	
	Inventory of DC Transmission Equipment	NERC 2-2	
	AC Circuit Outage Frequency by Outage Initiation Code		NERC 2-1
	AC Circuit Outage Duration by Outage Initiation Code		NERC 2-2
	DC Circuit Outage Frequency by Outage Initiation Code		NERC 2-3
	DC Circuit Outage Duration by Outage Initiation Code		NERC 2-4
	Transformer Outage Frequency by Outage Initiation Code		NERC 2-5
	Transformer Outage Duration by Outage Initiation Code		NERC 2-6
	AC/DC BTB Converter Outage Frequency by Outage Initiation Code		NERC 2-7
	AC/DC BTB Converter Outage Duration by Outage Initiation Code		NERC 2-8
	Event Types and Outages	NERC 2-3	
	3.1 AC Circuit Metrics and Data	AC Circuit Sustained Outage – Element-Initiated Only	NERC 3.1-1
AC Circuit Sustained Outage Metrics – Other than “Element-Initiated”		NERC 3.1-2	
AC Circuit Sustained Outages by Cause Code		NERC 3.1-3	
AC Circuit Sustained Outages – Other Attributes		NERC 3.1-4	
AC Circuit Momentary Outage Metrics – Element-Initiated Only		NERC 3.1-5	
AC Circuit Momentary Outage Metrics – Other than “Element-Initiated”		NERC 3.1-6	
AC Circuit Momentary Outages by Cause Code		NERC 3.1-7	
AC Circuit Momentary Outages – Other Attributes		NERC 3.1-8	
AC Circuit Metrics 1-16 per Appendix 2		NERC 3.1-9	
3.2 DC Circuit Metrics and Data	DC Circuit Sustained Outage Metrics and Data – Element-Initiated Only	NERC 3.2-1	
	DC Circuit Sustained Outage Metrics – Other than “Element-Initiated”	NERC 3.2-2	
	DC Circuit Sustained Outages by Cause Code	NERC 3.2-3	
	DC Circuit Sustained Outages – Other Attributes	NERC 3.2-4	
	DC Circuit Momentary Outage Metrics – Element-Initiated Only	NERC 3.2-5	
	DC Circuit Momentary Outage Metrics – Other than “Element-Initiated”	NERC 3.2-6	
	DC Circuit Momentary Outages by Cause Code	NERC 3.2-7	
	DC Circuit Momentary Outages – Other Attributes	NERC 3.2-8	
	DC Circuit Metrics 1-16 per Appendix 2	NERC 3.2-9	

Table NERC 1-1 (cont'd)

3.3 Transformer Metrics and Data	Transformer Sustained Outage Metrics – Element-Initiated Only	NERC 3.3-1	
	Transformer Sustained Outage Metrics – Other than “Element-Initiated”	NERC 3.3-2	
	Transformer Sustained Outages by Cause Code	NERC 3.3-3	
	Transformer Sustained Outages – Other Attributes	NERC 3.3-4	
	Transformer Momentary Outage Metrics – Element-Initiated Only	NERC 3.3-5	
	Transformer Momentary Outage Metrics – Other than “Element-Initiated”	NERC 3.3-6	
	Transformer Momentary Outages by Cause Code	NERC 3.3-7	
	Transformer Momentary Outages – Other Attributes	NERC 3.3-8	
	Transformer Metrics 1-10 per Appendix 2	NERC 3.3-9	
3.4 AC/DC BTB Converter Metrics and Data	AC/DC BTB Converter Sustained Outage Metrics – Element-Initiated Only	NERC 3.4-1	
	AC/DC BTB Converter Sustained Outage Metrics – Other than “Element-Initiated”	NERC 3.4-2	
	AC/DC BTB Converter Sustained Outages by Cause Code	NERC 3.4-3	
	AC/DC BTB Converter Sustained Outages – Other Attributes	NERC 3.4-4	
	AC/DC BTB Converter Momentary Outage Metrics – Element-Initiated Only	NERC 3.4-5	
	AC/DC BTB Converter Momentary Outage Metrics – Other than “Element-Initiated”	NERC 3.4-6	
	AC/DC BTB Converter Momentary Outages by Cause Code	NERC 3.4-7	
	AC/DC BTB Converter Momentary Outages – Other Attributes	NERC 3.4-8	
	AC/DC BTB Converter Metrics 1-10 per Appendix 2	NERC 3.4-9	

Tables omitted because they have no data, contain confidential TO data, or have no reported outages are shaded as follows:

Table NERC 1-2
Categories Displayed in Report Tables and Figures with Performance Data
Based upon the NERC Inventory⁵

No categories of this type exist within NERC

Category	Voltage Class	Construction type (Overhead or Underground)	
		OH	UG
AC Circuit	200-299 kV	OH	UG
	300-399 kV	OH	UG
	400-599 kV	OH	UG
	600-799 kV	OH	UG
AC Multi-Circuit Structure Miles	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		
	Mixed Voltages		
DC Circuit	200-299 kV	OH	UG
	300-399 kV	OH	UG
	400-499 kV	OH	UG
	500-599 kV	OH	UG
	600-799 kV	OH	UG
DC Multi-Circuit Structure Miles	200-299 kV		
	300-399 kV		
	400-499 kV		
	500-599 kV		
	600-799 kV		
	Mixed Voltages		
Transformers	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		
AC/DC BTB Converters	200-299 kV		
	300-399 kV		
	400-599 kV		
	600-799 kV		

⁵ For performance tables and figures, only the categories above are shown. As noted in Section 1.6.2, Tables 2-1 and 2-2 have inventory data for all the Voltage Classes.

2 NERC Metrics and Data Summary

This section reports overall Element inventory data as well as two measures of Element performance - outage frequency for both Sustained and Momentary Outage Frequency (SOF and MOF) and Sustained Outage Duration Time (SODT) – on a per Element basis. The number of Elements shown in the inventory data was used to compute the “per Element” frequency and duration metrics. Figure NERC 2-1 through Figure NERC 2-8 show frequency and duration metrics on a different scale for each Element. The scale was dictated by the Element’s data. Finally, the report provides the number and percentage of Events for each Event Type.

2.1 Element Inventory Data

The inventory data, summarized in two tables, NERC 2-1 and NERC 2-2 shows the average Element inventory for calendar year 2009 for AC transmission equipment and DC transmission equipment respectively. All Voltage Classes available for collection are included in these tables. Because TADS uses an equivalent (or average) inventory, the number of reported Elements will generally not be a whole number. As an example, an AC Circuit that is added in the middle of a reporting period will be shown as 0.5 of an AC Circuit in the inventory. This accurately reflects the exposure of Elements to outages.

2.2 Element Outage Frequency and Duration Metrics

Two figures for each TADS Element (AC Circuits, DC Circuits, Transformers, and AC/DC Back-to-Back Converters) are shown in this section.

- The first figure shows the Sustained Outage and Momentary Outage Frequency (SOF and MOF) by Outage Initiation Code.
- The second figure shows the Sustained Outage Duration Time per Element (SODT) by Outage Initiation Code.

**Table NERC 2-1
Inventory of AC Transmission Equipment**

Name	200-299 kV		300-399 kV		400-599 kV		600-799 kV		Mixed Voltages		All Voltages	
	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles
AC Circuit - All	4477.5	103558	1623.6	56791	594.7	32184	110	9451			6805.7	201985
Overhead	4363.5	103039	1559.6	56338	592.7	32099	110	9451			6625.8	200927
Underground	114.0	519	64	453	2	85	0	0			180	1058
AC Multi-Circuit Structure Miles*		17140		8548		1944		0		540		28173
Transformer	32		164.9		415.7		93				705.6	

* The data shown for AC Multi-Circuit Structure Miles is Multi-Circuit Structure Miles, not Circuit Miles.

**Table NERC 2-2
Inventory of DC Transmission Equipment**

Name	200-299 kV		300-399 kV		400-499 kV		500-599 kV		600-799 kV		All Voltages	
	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles	Equiv. No. Elements	Circuit Miles
DC Circuit - All	4	1022	0	0	10	2920	7	3368	0	0	21	7310
Overhead	4	1022	0	0	8	2917	6	3302	0	0	18	7241
Underground	0	0	0	0	2	3	1	66	0	0	3	69
DC Multi-Circuit Structure Miles*		511		0		1458		1651		0		3620
Name	200-299 kV		300-399 kV		400-599 kV				600-799 kV		All Voltages	
AC/DC BTB Converters**	7		7		0				0		14	

* The data shown for DC Multi-Circuit Structure Miles is Multi-Circuit Structure Miles, not Circuit Miles.

** AC/DC BTB Converter Voltage Classes are the highest AC Voltage Class of the two AC voltages on either side of the converter.

Figure NERC 2-1
AC Circuit Outage Frequency by Outage Initiation Code

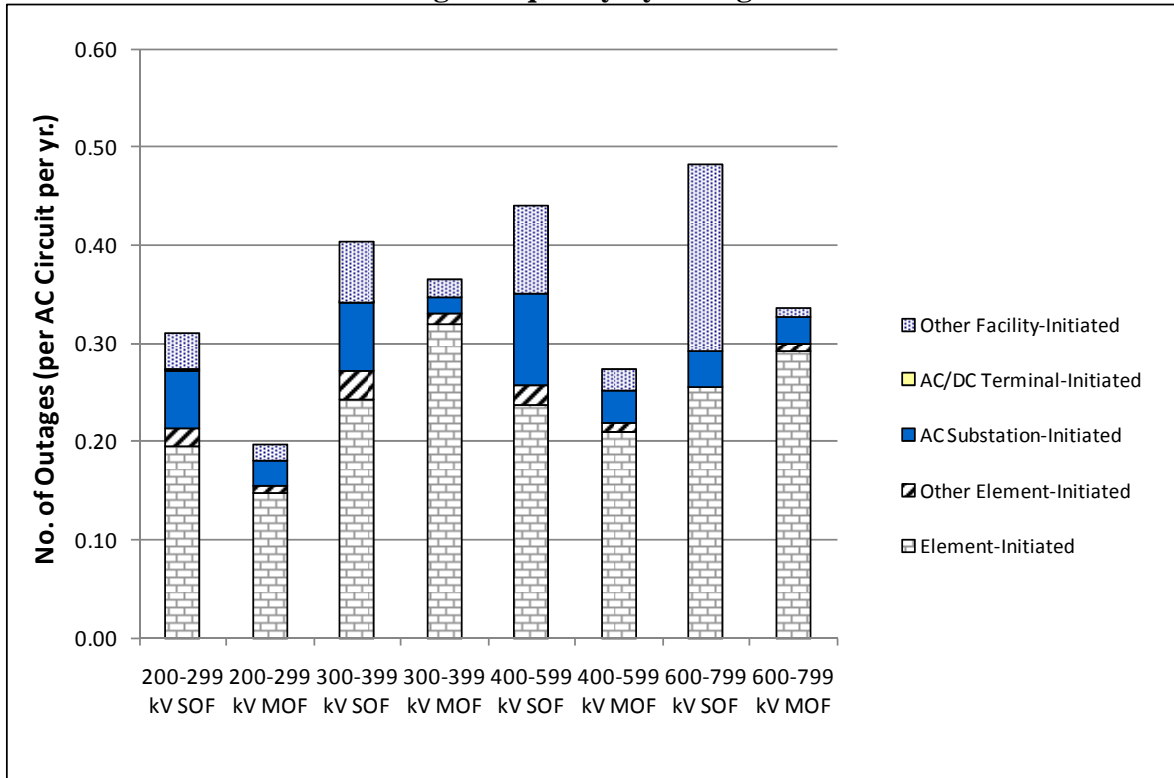


Figure NERC 2-2
AC Circuit Outage Duration by Outage Initiation Code

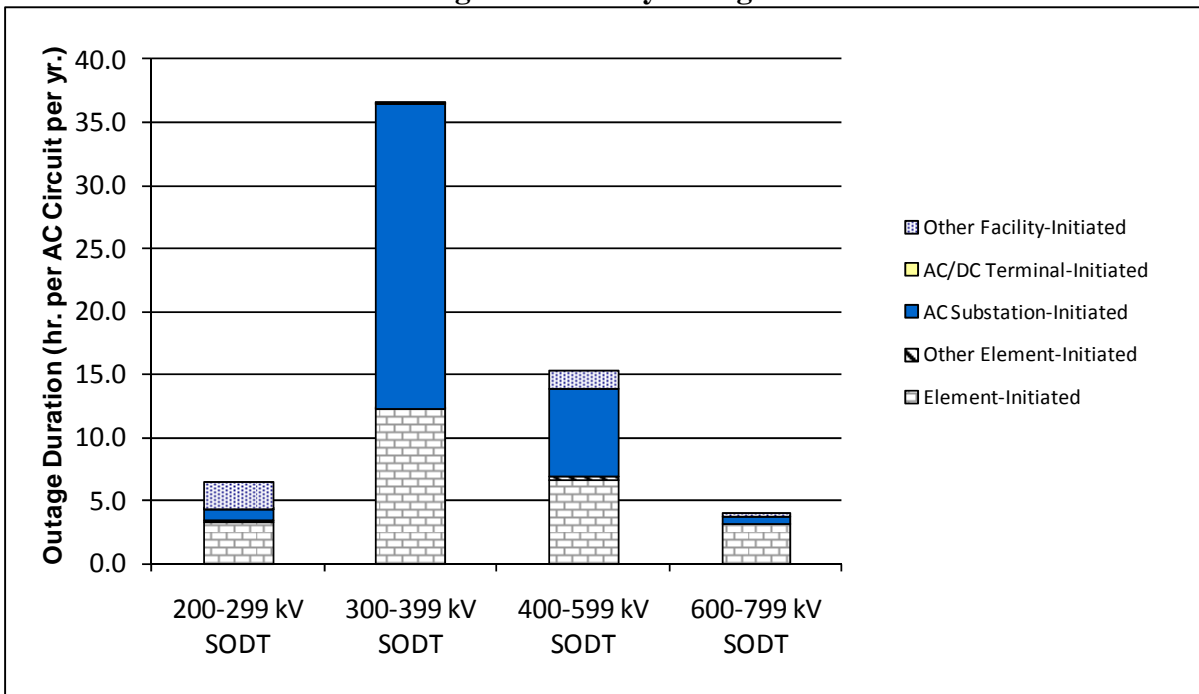


Figure NERC 2-3
DC Circuit Outage Frequency by Outage Initiation Code

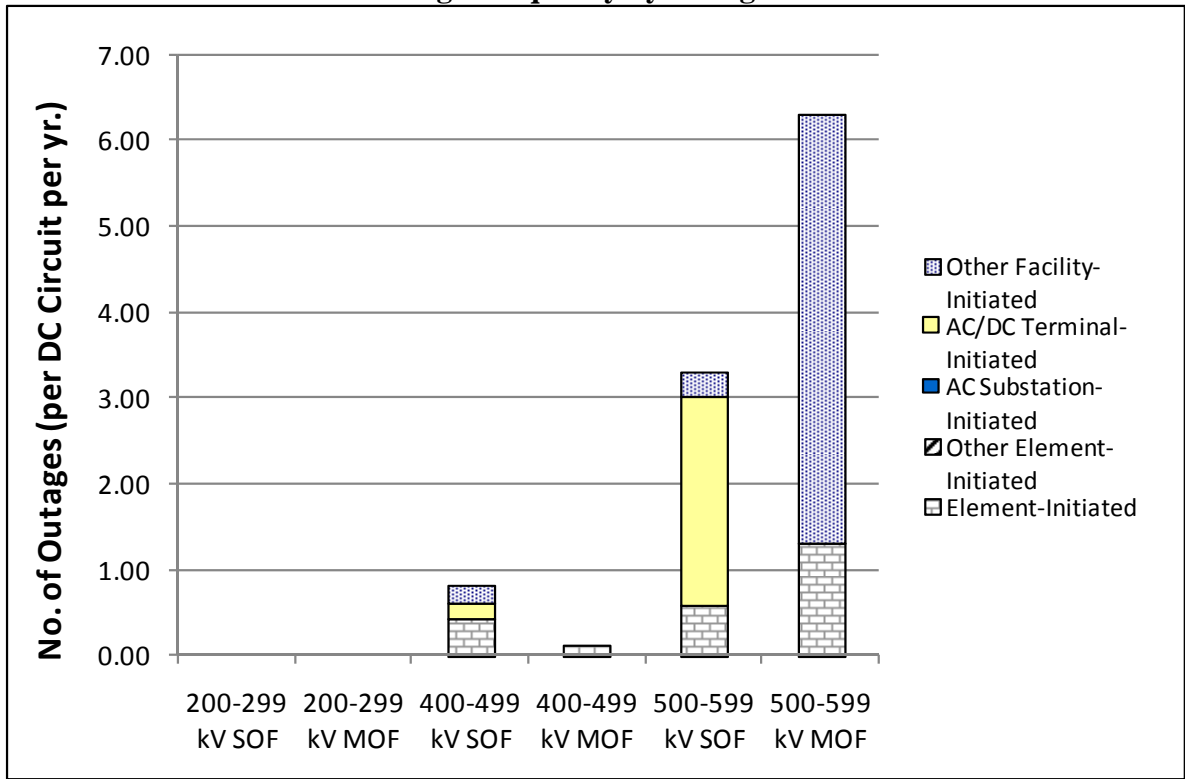
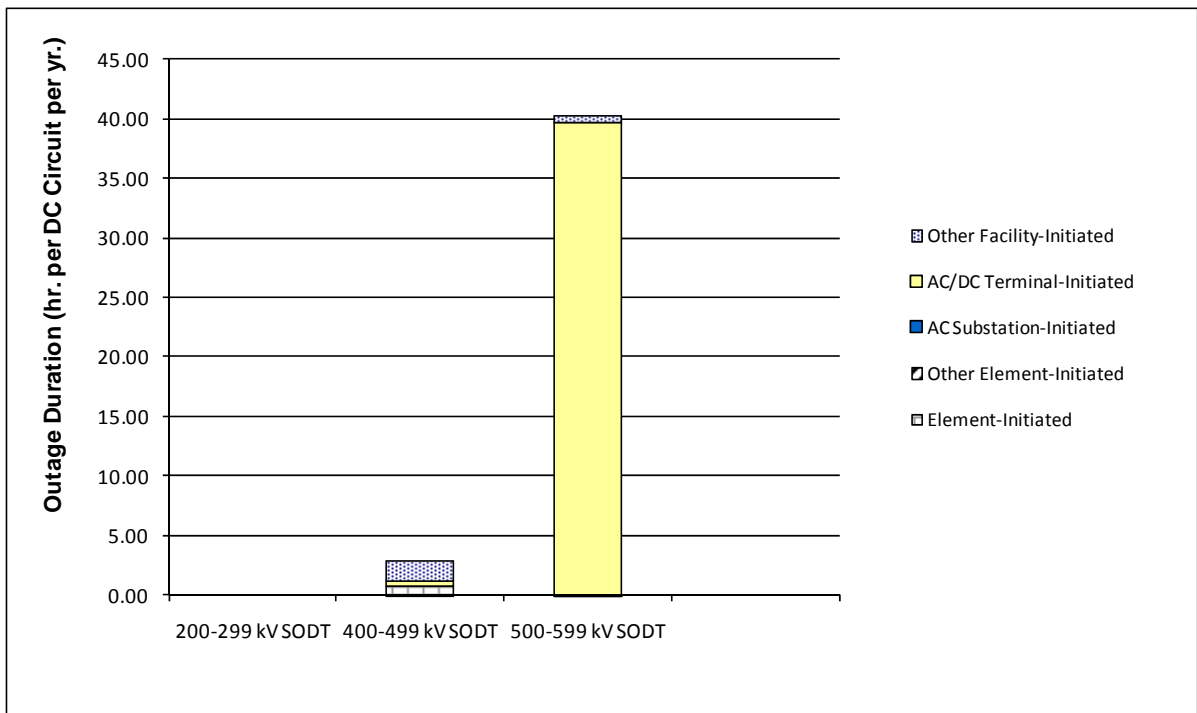
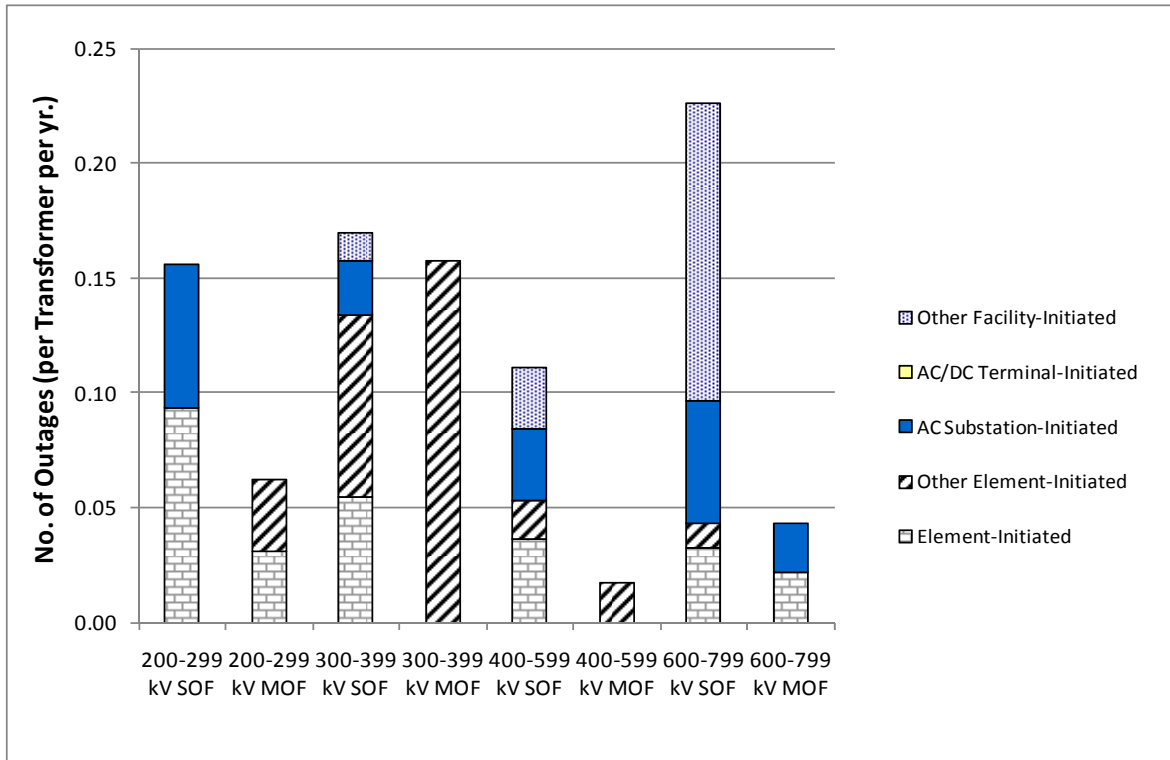


Figure NERC 2-4
DC Circuit Outage Duration by Outage Initiation Code



**Figure NERC 2-5
Transformer Outage Frequency by Outage Initiation Code**



**Figure NERC 2-6
Transformer Outage Duration by Outage Initiation**

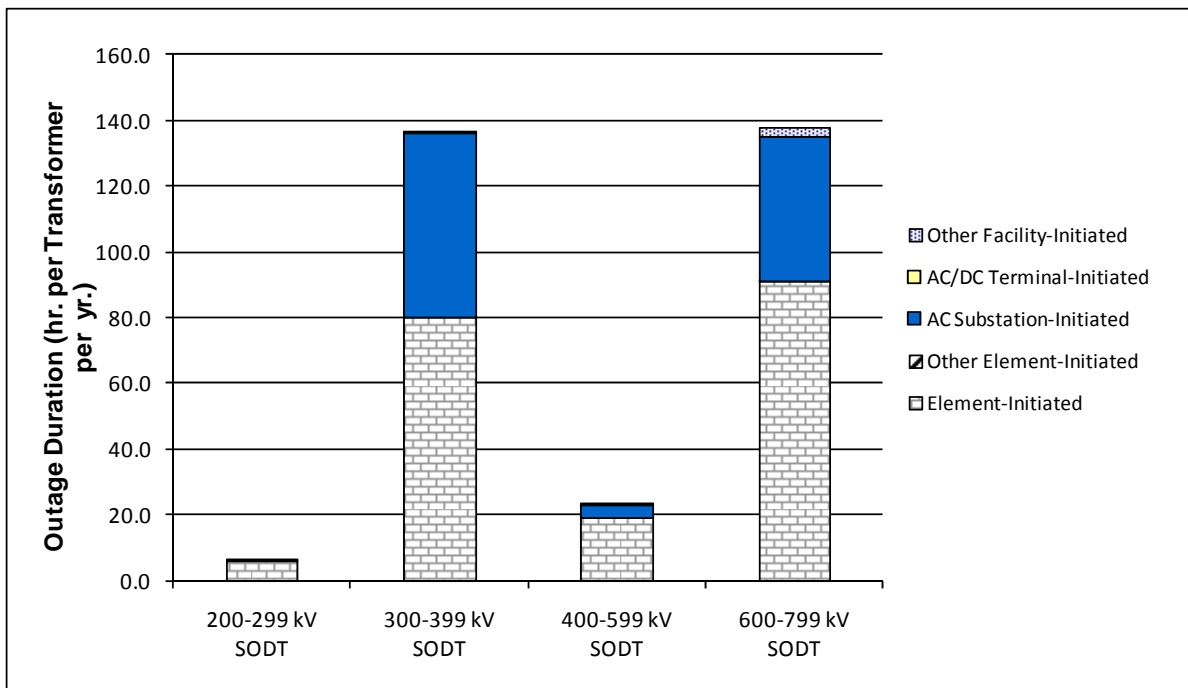


Figure NERC 2-7
AC/DC BTB Converter Outage Frequency by Outage Initiation Code

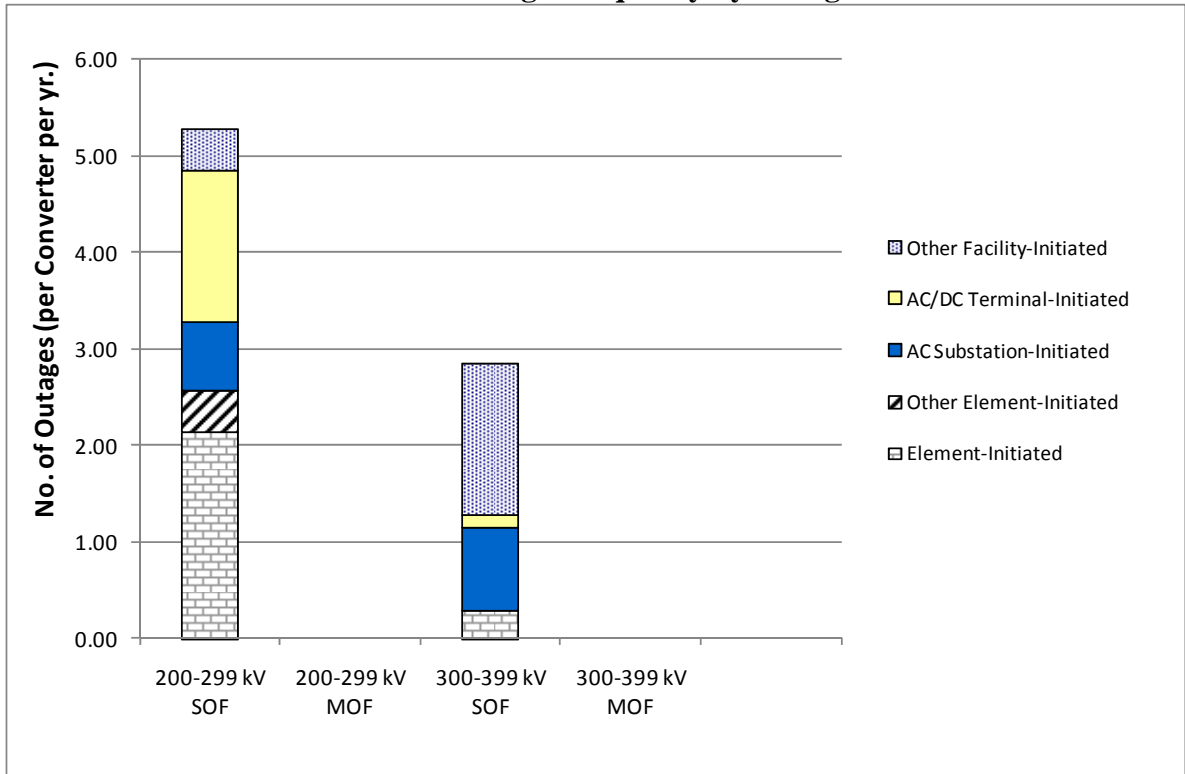
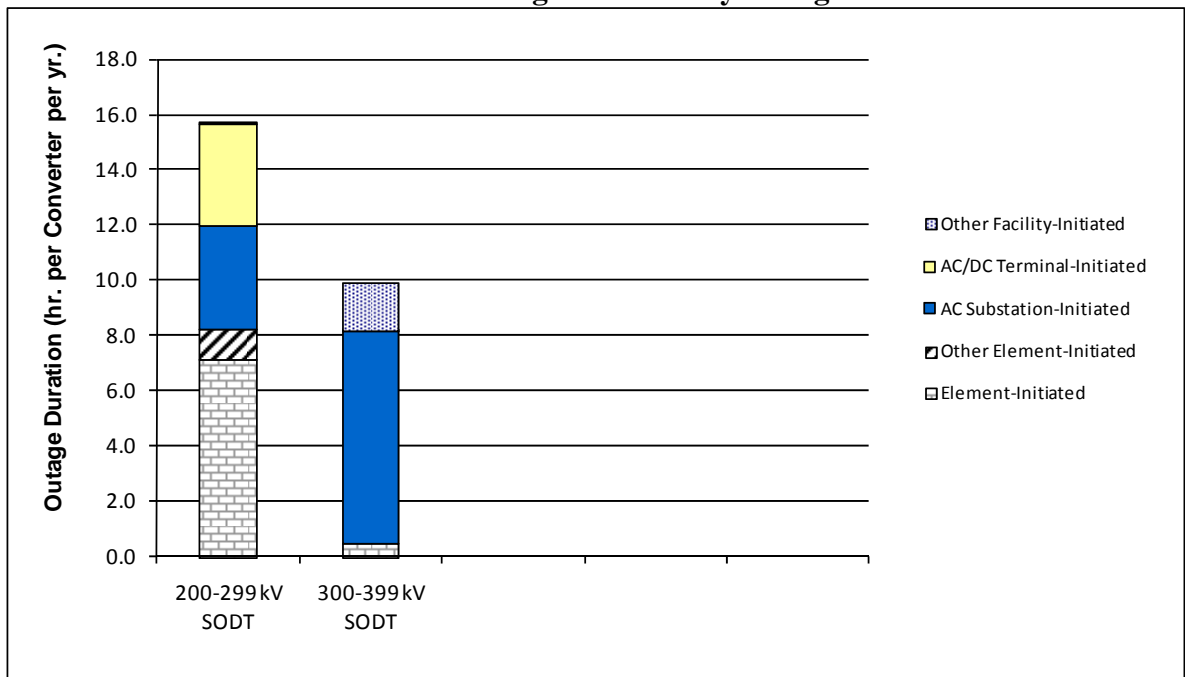


Figure NERC 2-8
AC/DC BTB Converter Outage Duration by Outage Initiation Code



2.3 Event Types

Event Type data, shown in Table NERC 2-3 below, provides the number and percentage of Events by Event Type as well as the number of outages associated with each Event. See the Event Type 10, 20, 30, 40, and 50 descriptions below.

Each Element outage, Sustained and Momentary, is assigned an Event Type. An Event may contain any number of Sustained and/or Momentary Outages and may include an outage from any type of Element; i.e. AC Circuit, DC Circuit, Transformer, or AC/DC BTB Converter. However, as defined, Event Types 10 and 20 involve only one Element outage, with Event Type 10 involving only an AC Circuit or a Transformer, and Event Type 20 involving a DC Circuit. Event Types 30 and 40 involve two AC Circuit and DC Circuit outages, respectively. Event Type 50 includes all other single or multiple outages not included elsewhere.

The Event Type data below has none of the confidential data exclusions described in Section 1.5. There are two reasons that the exclusions were not applied. First, no TO-specific performance data can be discerned. Second, because Event Types data are intended to include outages of more than one Element, it was not possible to delete confidential TO data without distorting the Event Type data.

**Table NERC 2-3
Event Type # and Outages**

Event Type #	Events		Outages	
	# Events	%	# Outages	%
10	2948	75.5%	2953	68.0%
20	106	2.7%	106	2.4%
30	88	2.3%	201	4.6%
40	2	0.1%	4	0.1%
50	761	19.5%	1080	24.9%
TOTAL	3905	100.0%	4344	100.0%

Event Type	Description
10	Automatic Outage of an AC Circuit or Transformer with Normal Clearing.
20	Automatic Outage of a DC Circuit with Normal Clearing.
30	Automatic Outage of two ADJACENT AC Circuits on common structures with Normal Clearing.
40	Automatic Outage of two ADJACENT DC Circuits on the common structures with Normal Clearing.
50	Other

3 NERC Metrics and Data Details

3.1 AC Circuit Metrics and Data

AC Circuit metrics are displayed in three sections: Section 3.1.1 addresses Sustained Outages and Section 3.1.2 addresses Momentary Outages. In all cases, the metrics displayed in these two sections include *all* AC Circuits (Overhead and Underground). Additionally, Section 3.1.3 has AC Circuit metrics that are differentiated into Overhead and Underground categories. Data and metrics are displayed for the four AC Voltage Classes in the NERC template plus the total of all Voltages Classes.

3.1.1 AC Circuit Sustained Outages

3.1.1.1 AC Circuit Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage was initiated.

- Table NERC 3.1-1 on the next page shows metrics for AC Circuit Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table NERC 3.1-2 on the next page shows the metrics for AC Circuit Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

**Table NERC 3.1-1
AC Circuit Sustained Outage Metrics - "Element-Initiated" Only**

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SCOF) (per 100 CM per yr)	Frequency (SOF) (per circuit per yr)	MTRR or Mean Outage Duration (hr)
200-299 kV	103558	4477.5	876	14789.6	0.8459	0.1956	16.9
300-399 kV	56791	1623.6	394	19766.8	0.6938	0.2427	50.2
400-599 kV	32184	594.7	141	3957.9	0.4381	0.2371	28.1
600-799 kV	9451	110.0	28	342.4	0.2963	0.2545	12.2
All Voltages	201985	6805.8	1439	38856.7	0.7124	0.2114	27.0

**Table NERC 3.1-2
AC Circuit Sustained Outage Metrics - Other than "Element-Initiated"**

Voltage Class	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per circuit per yr)	MTRR or Mean Outage Duration (hr)
200-299 kV	4477.5	509	13973.5	0.1137	27.5
300-399 kV	1623.6	260	39696.9	0.1601	152.7
400-599 kV	594.7	121	5101.5	0.2035	42.2
600-799 kV	110.0	25	99.5	0.2273	4.0
All Voltages	6805.8	915	58871.4	0.1344	64.3

3.1.1.2 AC Circuit Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table NERC 3.1-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table NERC 3.1-3 (p. 1 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	200-299 kV						300-399 kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	210	15.2%	139	10.0%	2426.9	8.4%	135	20.6%	104	15.9%	13878.6	23.3%
Lightning	203	14.7%	111	8.0%	301.3	1.0%	67	10.2%	54	8.3%	205.0	0.3%
Environmental	4	0.3%	8	0.6%	695.8	2.4%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	19	1.4%	19	1.4%	115.5	0.4%	6	0.9%	7	1.1%	34.9	0.1%
Foreign Interference	87	6.3%	71	5.1%	410.0	1.4%	15	2.3%	11	1.7%	379.6	0.6%
Fire	63	4.5%	43	3.1%	2239.3	7.8%	14	2.1%	13	2.0%	190.6	0.3%
Vandalism, Terrorism, or Malicious Acts	3	0.2%	4	0.3%	22.1	0.1%	1	0.2%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	156	11.3%	178	12.9%	12340.4	42.9%	60	9.2%	76	11.6%	1763.6	3.0%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	84	6.1%	98	7.1%	458.4	1.6%	46	7.0%	49	7.5%	257.8	0.4%
Failed AC Circuit Equipment	143	10.3%	178	12.9%	7248.3	25.2%	50	7.6%	62	9.5%	4743.0	8.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	20	1.4%	19	1.4%	170.2	0.6%	3	0.5%	2	0.3%	20.7	0.0%
Power System Condition	73	5.3%	95	6.9%	472.9	1.6%	7	1.1%	18	2.8%	101.0	0.2%
Human Error	125	9.0%	116	8.4%	114.5	0.4%	79	12.1%	71	10.9%	338.9	0.6%
Unknown	136	9.8%	199	14.4%	966.4	3.4%	111	17.0%	122	18.7%	1298.1	2.2%
Other	59	4.3%	107	7.7%	781.2	2.7%	60	9.2%	65	9.9%	36252.1	61.0%
TOTAL	1385	100.0%	1385	100.0%	28763.1	100.0%	654	100.0%	654	100.0%	59463.7	100.0%

Table NERC 3.1-3 (p. 2 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	400-599 kV						600-799 kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	33	12.6%	29	11.1%	2760.1	30.5%	11	20.8%	9	17.0%	176.0	39.8%
Lightning	29	11.1%	14	5.3%	67.8	0.7%	8	15.1%	8	15.1%	13.7	3.1%
Environmental	1	0.4%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	11	4.2%	10	3.8%	123.5	1.4%	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	14	5.3%	10	3.8%	5.8	0.1%	0	0.0%	0	0.0%	0.0	0.0%
Fire	7	2.7%	1	0.4%	0.1	0.0%	4	7.5%	4	7.5%	0.5	0.1%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	36	13.7%	36	13.7%	3837.7	42.4%	6	11.3%	4	7.5%	81.7	18.5%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	24	9.2%	26	9.9%	77.0	0.8%	4	7.5%	4	7.5%	21.9	5.0%
Failed AC Circuit Equipment	17	6.5%	28	10.7%	347.6	3.8%	1	1.9%	2	3.8%	63.7	14.4%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	1	1.9%	1	1.9%	8.8	2.0%
Power System Condition	19	7.3%	24	9.2%	86.0	0.9%	1	1.9%	3	5.7%	63.0	14.3%
Human Error	35	13.4%	33	12.6%	928.3	10.2%	6	11.3%	14	26.4%	8.8	2.0%
Unknown	32	12.2%	48	18.3%	725.5	8.0%	1	1.9%	2	3.8%	2.1	0.5%
Other	4	1.5%	3	1.1%	100.2	1.1%	10	18.9%	2	3.8%	1.6	0.4%
TOTAL	262	100.0%	262	100.0%	9059.4	100.0%	53	100.0%	53	100.0%	441.9	100.0%

Table NERC 3.1-3 (p. 3 of 3)
AC Circuit Sustained Outages by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	389	16.5%	281	11.9%	19241.6	19.7%
Lightning	307	13.0%	187	7.9%	587.8	0.6%
Environmental	5	0.2%	8	0.3%	695.8	0.7%
Contamination	36	1.5%	36	1.5%	273.9	0.3%
Foreign Interference	116	4.9%	92	3.9%	795.3	0.8%
Fire	88	3.7%	61	2.6%	2430.4	2.5%
Vandalism, Terrorism, or Malicious Acts	4	0.2%	4	0.2%	22.1	0.0%
Failed AC Substation Equipment	258	11.0%	294	12.5%	18023.4	18.4%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	158	6.7%	177	7.5%	815.1	0.8%
Failed AC Circuit Equipment	211	9.0%	270	11.5%	12402.6	12.7%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	24	1.0%	22	0.9%	199.6	0.2%
Power System Condition	100	4.2%	140	5.9%	722.9	0.7%
Human Error	245	10.4%	234	9.9%	1390.4	1.4%
Unknown	280	11.9%	371	15.8%	2992.1	3.1%
Other	133	5.6%	177	7.5%	37135.1	38.0%
TOTAL	2354	100.0%	2354	100.0%	97728.0	100.0%

3.1.1.3 Other AC Circuit Sustained Outage Data

Table NERC 3.1-4 on the next page shows other AC Circuit Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, Event Type, and Outage Duration Interval.

Table NERC 3.1-4 (p. 1 of 3)
AC Circuit - Other Sustained Outage Attributes

Fault Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	408	29.5%	4501.4	15.6%	282	43.1%	39816.9	67.0%	96	36.6%	1916.4	21.2%	31	58.5%	131.5	29.8%
P-P fault	147	10.6%	1537.9	5.3%	31	4.7%	235.4	0.4%	9	3.4%	5.7	0.1%	2	3.8%	0.1	0.0%
Single P-G fault	560	40.4%	16931.1	58.9%	231	35.3%	9014.5	15.2%	116	44.3%	4309.4	47.6%	16	30.2%	169.9	38.5%
P-P-G, 3 P, or 3P-G fault	118	8.5%	2892.0	10.1%	20	3.1%	3027.4	5.1%	12	4.6%	2179.2	24.1%	4	7.5%	140.4	31.8%
Unknown fault type	152	11.0%	2900.7	10.1%	90	13.8%	7369.6	12.4%	29	11.1%	648.8	7.2%	0	0.0%	0.0	0.0%
TOTAL	1385	100.0%	28763.1	100.0%	654	100.0%	59463.7	100.0%	262	100.0%	9059.4	100.0%	53	100.0%	441.9	100.0%

Outage Initiation Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	876	63.2%	14789.6	51.4%	394	60.2%	19766.8	33.2%	141	53.8%	1916.4	21.2%	31	58.5%	131.5	29.8%
Other Element-Initiated	82	5.9%	329.1	1.1%	46	7.0%	183.3	0.3%	12	4.6%	5.7	0.1%	2	3.8%	0.1	0.0%
AC Substation-Initiated	262	18.9%	3944.1	13.7%	113	17.3%	39123.6	65.8%	55	21.0%	4309.4	47.6%	16	30.2%	169.9	38.5%
AC/DC Terminal-Initiated	2	0.1%	336.1	1.2%	1	0.2%	0.6	0.0%	0	0.0%	2179.2	24.1%	4	7.5%	140.4	31.8%
Other Facility-Initiated	163	11.8%	9364.1	32.6%	100	15.3%	389.6	0.7%	54	20.6%	648.8	7.2%	0	0.0%	0.0	0.0%
TOTAL	1385	100.0%	28763.1	100.0%	654	100.0%	59463.7	100.0%	262	100.0%	9059.4	100.0%	53	100.0%	441.9	100.0%

Outage Mode Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	999	72.1%	24406.3	84.9%	447	68.3%	19766.8	33.2%	209	79.8%	8369.1	92.4%	28	52.8%	342.4	77.5%
Dependent Mode Initiating	60	4.3%	842.7	2.9%	65	9.9%	183.3	0.3%	5	1.9%	56.8	0.6%	0	0.0%	0.0	0.0%
Dependent Mode	163	11.8%	753.2	2.6%	75	11.5%	39123.6	65.8%	14	5.3%	25.4	0.3%	4	7.5%	59.5	13.5%
Common Mode	149	10.8%	2598.5	9.0%	58	8.9%	0.6	0.0%	30	11.5%	583.5	6.4%	0	0.0%	0.0	0.0%
Common Mode Initiating	14	1.0%	162.5	0.6%	9	1.4%	389.6	0.7%	4	1.5%	24.8	0.3%	21	39.6%	40.0	9.0%
TOTAL	1385	100.0%	28763.1	100.0%	654	100.0%	59463.7	100.0%	262	100.0%	9059.4	100.0%	53	100.0%	441.9	100.0%

Table NERC 3.1-4 (p. 2 of 3)
AC Circuit - Other Sustained Outage Attributes

Event Type #	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
10	942	68.0%	23294.7	81.0%	387	59.2%	7044.9	11.8%	188	71.8%	7511.8	82.9%	24	45.3%	321.2	72.7%
30	118	8.5%	2374.5	8.3%	32	4.9%	4171.7	7.0%	1	0.4%	0.0	0.0%	2	3.8%	6.6	1.5%
50	325	23.5%	3093.9	10.8%	235	35.9%	48247.1	81.1%	73	27.9%	1547.6	17.1%	27	50.9%	114.1	25.8%
TOTAL	1385	100.0%	28763.1	100.0%	654	100.0%	59463.7	100.0%	262	100.0%	9059.4	100.0%	53	100.0%	441.9	100.0%

Outage Duration Interval	200-299 kV		300-399 kV		400-599 kV		600-799 kV	
	No. Sust.	%	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	377	27.2%	165	25.2%	83	31.7%	10	18.9%
6-10 Minutes	135	9.7%	49	7.5%	27	10.3%	4	7.5%
11-30 Minutes	143	10.3%	71	10.9%	39	14.9%	8	15.1%
31-120 Minutes	176	12.7%	87	13.3%	30	11.5%	11	20.8%
121 Minutes to 24 Hours	432	31.2%	199	30.4%	45	17.2%	15	28.3%
> 24 Hours to 48 Hours	54	3.9%	36	5.5%	12	4.6%	2	3.8%
> 48 Hours	68	4.9%	47	7.2%	26	9.9%	3	5.7%
TOTAL	1385	100.0%	654	100.0%	262	100.0%	53	100.0%

Table NERC 3.1-4 (p. 3 of 3)
AC Circuit - Other Sustained Outage Attributes

Fault Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
No fault	817	34.7%	46366.1	47.4%
P-P fault	189	8.0%	1779.1	1.8%
Single P-G fault	923	39.2%	30424.8	31.1%
P-P-G, 3 P, or 3P-G fault	154	6.5%	8239.0	8.4%
Unknown fault type	271	11.5%	10919.1	11.2%
TOTAL	2354	100.0%	97728.0	100.0%

Outage Initiation Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	1442	61.3%	36604.2	37.5%
Other Element-Initiated	142	6.0%	518.2	0.5%
AC Substation-Initiated	446	18.9%	47547.0	48.7%
AC/DC Terminal-Initiated	7	0.3%	2656.3	2.7%
Other Facility-Initiated	317	13.5%	10402.4	10.6%
TOTAL	2354	100.0%	97728.0	100.0%

Outage Mode Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Single Mode	1683	71.5%	52884.5	54.1%
Dependent Mode Initiating	130	5.5%	1082.8	1.1%
Dependent Mode	256	10.9%	39961.6	40.9%
Common Mode	237	10.1%	3182.5	3.3%
Common Mode Initiating	48	2.0%	616.7	0.6%
TOTAL	2354	100.0%	97728.0	100.0%

Event Type #	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
10	1541	65.5%	38172.6	39.1%
30	153	6.5%	6552.8	6.7%
50	660	28.0%	53002.6	54.2%
TOTAL	2354	100.0%	97728.0	100.0%

Outage Duration Interval	All Voltages	
	No. Sust.	%
1-5 Minutes	635	27.0%
6-10 Minutes	215	9.1%
11-30 Minutes	261	11.1%
31-120 Minutes	304	12.9%
121 Minutes to 24 Hours	691	29.4%
> 24 Hours to 48 Hours	104	4.4%
> 48 Hours	144	6.1%
TOTAL	2354	100.0%

3.1.2 AC Circuit Momentary Outages

3.1.2.1 AC Circuit Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage was initiated.

- Table NERC 3.1-5 shows metrics for AC Circuit Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table NERC 3.1-6 shows the metrics for AC Circuit Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

Table NERC 3.1-5

AC Circuit Momentary Outage Metrics - "Element-Initiated" Only

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Frequency (MCOF) (per 100 CM per yr)	Frequency (MOF) (per circuit per yr)
200-299 kV	103558	4477.5	661	0.6383	0.1476
300-399 kV	56791	1623.6	519	0.9139	0.3197
400-599 kV	32184	594.7	125	0.3884	0.2102
600-799 kV	9451	110.0	32	0.3386	0.2909
All Voltages	201985	6805.8	1337	0.6619	0.1965

Table NERC 3.1-6

AC Circuit Momentary Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Circuits	No. of Outages	Frequency (MOF) (per circuit per yr)
200-299 kV	4477.5	223	0.0498
300-399 kV	1623.6	73	0.0450
400-599 kV	594.7	38	0.0639
600-799 kV	110.0	5	0.0455
All Voltages	6805.8	339	0.0498

3.1.2.2 AC Circuit Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table NERC 3.1-7 reports Cause Code data for AC Circuit Momentary Outages.

**Table NERC 3.1-7
AC Circuit Momentary Outages by Cause Code**

Outage Cause Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	88	10.0%	83	14.0%	10	6.1%	12	32.4%	193	11.5%
Lightning	290	32.8%	162	27.4%	58	35.6%	10	27.0%	520	31.0%
Environmental	0	0.0%	1	0.2%	0	0.0%	0	0.0%	1	0.1%
Contamination	19	2.1%	34	5.7%	8	4.9%	0	0.0%	61	3.6%
Foreign Interference	65	7.4%	18	3.0%	5	3.1%	1	2.7%	89	5.3%
Fire	15	1.7%	5	0.8%	1	0.6%	2	5.4%	23	1.4%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed AC Substation Equipment	25	2.8%	20	3.4%	1	0.6%	3	8.1%	49	2.9%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed Protection System Equipment	65	7.4%	28	4.7%	9	5.5%	0	0.0%	102	6.1%
Failed AC Circuit Equipment	37	4.2%	21	3.5%	9	5.5%	0	0.0%	67	4.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Vegetation	4	0.5%	2	0.3%	0	0.0%	0	0.0%	6	0.4%
Power System Condition	48	5.4%	0	0.0%	0	0.0%	0	0.0%	48	2.9%
Human Error	56	6.3%	12	2.0%	6	3.7%	2	5.4%	76	4.5%
Unknown	157	17.8%	189	31.9%	56	34.4%	6	16.2%	408	24.3%
Other	15	1.7%	17	2.9%	0	0.0%	1	2.7%	33	2.0%
TOTAL	884	100.0%	592	100.0%	163	100.0%	37	100.0%	1676	100.0%

3.1.2.3 Other AC Circuit Momentary Outage Data

Table NERC 3.1-8 on the next page shows other AC Circuit Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table NERC 3.1-8
AC Circuit - Other Momentary Outage Attributes**

Fault Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	177	20.0%	174	29.4%	13	8.0%	22	59.5%	386	23.0%
P-P fault	36	4.1%	9	1.5%	1	0.6%	0	0.0%	46	2.7%
Single P-G fault	523	59.2%	327	55.2%	124	76.1%	15	40.5%	989	59.0%
P-P-G, 3 P, or 3P-G fault	70	7.9%	8	1.4%	8	4.9%	0	0.0%	86	5.1%
Unknown fault type	78	8.8%	74	12.5%	17	10.4%	0	0.0%	169	10.1%
TOTAL	884	100.0%	592	100.0%	163	100.0%	37	100.0%	1676	100.0%

Outage Initiation Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	661	74.8%	519	87.7%	125	76.7%	32	86.5%	1337	79.8%
Other Element-Initiated	29	3.3%	16	2.7%	5	3.1%	1	2.7%	51	3.0%
AC Substation-Initiated	115	13.0%	29	4.9%	20	12.3%	3	8.1%	167	10.0%
AC/DC Terminal-Initiated	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other Facility-Initiated	79	8.9%	28	4.7%	13	8.0%	1	2.7%	121	7.2%
TOTAL	884	100.0%	592	100.0%	163	100.0%	37	100.0%	1676	100.0%

Outage Mode Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	696	78.7%	414	69.9%	152	93.3%	13	35.1%	1275	76.1%
Dependent Mode Initiating	25	2.8%	124	20.9%	4	2.5%	22	59.5%	175	10.4%
Dependent Mode	95	10.7%	24	4.1%	4	2.5%	1	2.7%	124	7.4%
Common Mode	65	7.4%	27	4.6%	3	1.8%	0	0.0%	95	5.7%
Common Mode Initiating	3	0.3%	3	0.5%	0	0.0%	1	2.7%	7	0.4%
TOTAL	884	100.0%	592	100.0%	163	100.0%	37	100.0%	1676	100.0%

Event Type #	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
10	706	79.9%	501	84.6%	146	89.6%	28	75.7%	1381	82.4%
30	39	4.4%	5	0.8%	3	1.8%	0	0.0%	47	2.8%
50	139	15.7%	86	14.5%	14	8.6%	9	24.3%	248	14.8%
TOTAL	884	100.0%	592	100.0%	163	100.0%	37	100.0%	1676	100.0%

3.1.3 Total AC Circuit Metrics

Table NERC 3.1-9 on the next page displays AC Circuit metrics that are defined in Appendix 2.

**Table NERC 3.1-9
AC Circuit Metrics 1-16 per Appendix 2**

Voltage Class	OH/UG	Element Outage Duration, Repair Time, and Update Time (4-7)									Element Availability (8-10)		
		Element Outage Frequency (1-3)			SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
		TOF	SOF	MOF		P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	Overhead	0.52	0.31	0.20	6.39	20.34	20.34	20.34	0.68	27859.21	99.92	69.23	2.27
300-399 kV	Overhead	0.79	0.41	0.38	37.79	92.51	92.51	92.52	0.93	21355.0	99.57	62.07	1.14
400-599 kV	Overhead	0.72	0.44	0.28	15.28	34.57	34.58	34.58	0.32	19782.2	99.82	66.67	1.18
600-799 kV	Overhead	0.82	0.48	0.34	4.02	8.32	8.34	8.35	0.88	18172.8	99.95	53.64	0.00
200-299 kV	Underground	0.18	0.12	0.05	7.71	60.71	62.79	64.87	1.72	71268.64	99.91	87.61	0.00
300-399 kV	Underground	0.28	0.27	0.02	8.31	30.66	31.29	31.93	6.95	32947.5	99.91	78.13	0.00
400-599 kV	Underground	C	C	C	C	C	C	C	C	C	C	C	C

Voltage Class	OH/UG	Circuit Outage Frequency (11-13)						Multiple Circuit Outage Frequency (14-16)			Outage Totals		
		TCOF		SCOF		MCOF		TMCOF	SMCOF	MMCOF	Momentary Outages	Sustained Outages	Sustained Outages Hours
		All	Elemt. Init.	All	Elemt. Init.	All	Elemt. Init.						
200-299 kV	Overhead	2.18	1.49	1.33	0.85	0.85	0.64	0.53	0.42	0.13	878	1371	27884.1
300-399 kV	Overhead	2.18	1.62	1.13	0.70	1.05	0.92	0.23	0.22	0.05	591	637	58931.7
400-599 kV	Overhead	1.32	0.83	0.82	0.44	0.51	0.39	0.15	0.05	0.10	163	262	9059.4
600-799 kV	Overhead	0.95	0.63	0.56	0.30	0.39	0.34	-	-	-	37	53	441.9
Mixed Voltages	Overhead							0.00	0.00	0.00			
200-299 kV	Underground	3.86	0.96	2.70	0.96	1.16	0.00				6	14	879.0
300-399 kV	Underground	3.97	0.22	3.75	0.22	0.22	0.00				1	17	532.0
400-599 kV	Underground	C	C	C	C	C	C				C	C	C
TOTAL											1676	2354	97728.0

3.2 DC Circuit Metrics and Data

DC Circuit metrics are displayed in three sections: Section 3.2.1 addresses Sustained Outages and Section 3.2.2 addresses Momentary Outages. In all cases, the metrics displayed in these two sections include *all* DC Circuits (Overhead and Underground). Additionally, Section 3.1.3 has DC Circuit metrics that are differentiated into Overhead and Underground categories. Data and metrics are displayed for the three DC Circuit Voltage Classes in the NERC template plus the total of all Voltage Classes.

3.2.1 DC Circuit Sustained Outages

3.2.1.1 DC Circuit Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.2-1 on the next page shows metrics for DC Circuit Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (DC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table NERC 3.2-2 on the next page shows the metrics for DC Circuit Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

Table NERC 3.2-1

DC Circuit Sustained Outage Metrics - "Element-Initiated" Only

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SCOF) (per 100 CM per yr)	Frequency (SOF) (per circuit per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	NC	NC	C	C	C	C	C
400-499 kV	2920	10.0	4	8.37	0.1370	0.4000	2.1
500-599 kV	3368	7.0	4	1.00	0.1188	0.5714	0.3
All Voltages	6288	17.0	8	9.37	0.1272	0.4706	1.2

Table NERC 3.2-2

DC Circuit Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Circuits	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per circuit per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	NC	C	C	C	C
400-499 kV	10.0	4	21.18	0.4000	5.3
500-599 kV	7.0	19	280.63	2.7143	14.8
All Voltages	17.0	23	301.81	1.3529	13.1

3.2.1.2 DC Circuit Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table NERC 3.2-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table NERC 3.2-3 (p. 1 of 2)
DC Circuit Sustained Outages by Cause Code

Outage Cause Code	200-299 kV						400-499 kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	C	C	C	C	C	C	2	25.0%	2	25.0%	2.4	8.0%
Lightning	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Environmental	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Contamination	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Fire	C	C	C	C	C	C	2	25.0%	2	25.0%	6.0	20.3%
Vandalism, Terrorism, or Malicious Acts	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Failed AC/DC Terminal Equipment	C	C	C	C	C	C	2	25.0%	2	25.0%	3.8	12.8%
Failed Protection System Equipment	C	C	C	C	C	C	2	25.0%	1	12.5%	1.1	3.7%
Failed AC Circuit Equipment	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Failed DC Circuit Equipment	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Human Error	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Unknown	C	C	C	C	C	C	0	0.0%	0	0.0%	0.0	0.0%
Other	C	C	C	C	C	C	0	0.0%	1	12.5%	16.3	55.2%
TOTAL	C	C	C	C	C	C	8	100.0%	8	100.0%	29.6	100.0%

Table NERC 3.2-3 (p. 2 of 2)
DC Circuit Sustained Outages by Cause Code

Outage Cause Code	500-599 kV						All Voltages					
	No. Int.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Int.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	5	21.7%	4	17.4%	1.5	0.5%	7	22.6%	6	19.4%	3.8	1.2%
Lightning	1	4.3%	0	0.0%	0.0	0.0%	1	3.2%	0	0.0%	0.0	0.0%
Environmental	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%	2	6.5%	2	6.5%	6.0	1.9%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC/DC Terminal Equipment	12	52.2%	9	39.1%	274.8	97.6%	14	45.2%	11	35.5%	278.6	89.5%
Failed Protection System Equipment	1	4.3%	1	4.3%	0.5	0.2%	3	9.7%	2	6.5%	1.6	0.5%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	1	4.3%	1	4.3%	0.7	0.2%	1	3.2%	1	3.2%	0.7	0.2%
Human Error	1	4.3%	0	0.0%	0.0	0.0%	1	3.2%	0	0.0%	0.0	0.0%
Unknown	2	8.7%	8	34.8%	4.1	1.5%	2	6.5%	8	25.8%	4.1	1.3%
Other	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	1	3.2%	16.3	5.2%
TOTAL	23	100.0%	23	100.0%	281.6	100.0%	31	100.0%	31	100.0%	311.2	100.0%

3.2.1.3 Other DC Circuit Sustained Outage Data

Table NERC 3.2-4 on the next page shows other DC Circuit Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, Event Type, and Outage Duration Interval.

Table NERC 3.2-4 (p. 1 of 2)
DC Circuit - Other Sustained Outage Attributes

Fault Type	200-299 kV				400-499 kV				500-599 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	C	C	C	C	4	50.0%	21.2	71.7%	14	60.9%	276.8	98.3%	18	58.1%	298.0	95.8%
P-P fault	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
Single P-G fault	C	C	C	C	2	25.0%	6.0	20.3%	4	17.4%	1.5	0.5%	6	19.4%	7.5	2.4%
P-P-G, 3 P, or 3P-G fault	C	C	C	C	2	25.0%	2.4	8.0%	1	4.3%	2.5	0.9%	3	9.7%	4.8	1.6%
Unknown fault type	C	C	C	C	0	0.0%	0.0	0.0%	4	17.4%	0.9	0.3%	4	12.9%	0.9	0.3%
TOTAL	C	C	C	C	8	100.0%	29.6	100.0%	23	100.0%	281.6	100.0%	31	100.0%	311.2	100.0%

Outage Initiation Code	200-299 kV				400-499 kV				500-599 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	C	C	C	C	4	50.0%	8.4	28.3%	4	17.4%	1.0	0.4%	8	25.8%	9.4	3.0%
Other Element-Initiated	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
AC Substation-Initiated	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
AC/DC Terminal-Initiated	C	C	C	C	2	25.0%	3.8	12.8%	17	73.9%	277.4	98.5%	19	61.3%	281.1	90.3%
Other Facility-Initiated	C	C	C	C	2	25.0%	17.4	59.0%	2	8.7%	3.3	1.2%	4	12.9%	20.7	6.7%
TOTAL	C	C	C	C	8	100.0%	29.6	100.0%	23	100.0%	281.6	100.0%	31	100.0%	311.2	100.0%

Outage Mode Code	200-299 kV				400-499 kV				500-599 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	C	C	C	C	2	25.0%	17.4	59.0%	16	69.6%	266.8	94.7%	18	58.1%	284.3	91.3%
Dependent Mode Initiating	C	C	C	C	2	25.0%	4.1	13.9%	0	0.0%	0.0	0.0%	2	6.5%	4.1	1.3%
Dependent Mode	C	C	C	C	4	50.0%	8.0	27.2%	7	30.4%	14.8	5.3%	11	35.5%	22.8	7.3%
Common Mode	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
Common Mode Initiating	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	C	C	C	C	8	100.0%	29.6	100.0%	23	100.0%	281.6	100.0%	31	100.0%	311.2	100.0%

Table NERC 3.2-4 (p. 2 of 2)
DC Circuit - Other Sustained Outage Attributes

Event Type #	200-299 kV				400-499 kV				500-599 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
20	C	C	C	C	2	25.0%	3.8	12.8%	21	91.3%	280.8	99.7%	23	74.2%	284.6	91.5%
40	C	C	C	C	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
50	C	C	C	C	6	75.0%	25.8	87.2%	2	8.7%	0.8	0.3%	8	25.8%	26.6	8.5%
TOTAL	C	C	C	C	8	100.0%	29.6	100.0%	23	100.0%	281.6	100.0%	31	100.0%	311.2	100.0%

DC Circuit - Sustained Outage Duration Intervals

Outage Duration Interval	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Sust.	%	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	C	C	0	0.0%	1	4.3%	1	3.2%
6-10 Minutes	C	C	0	0.0%	1	4.3%	1	3.2%
11-30 Minutes	C	C	0	0.0%	8	34.8%	8	25.8%
31-120 Minutes	C	C	4	50.0%	7	30.4%	11	35.5%
121 Minutes to 24 Hours	C	C	4	50.0%	5	21.7%	9	29.0%
> 24 Hours to 48 Hours	C	C	0	0.0%	0	0.0%	0	0.0%
> 48 Hours	C	C	0	0.0%	1	4.3%	1	3.2%
TOTAL	C	C	8	100.0%	23	100.0%	31	100.0%

3.2.2 DC Circuit Momentary Outages

3.2.2.1 DC Circuit Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.2-5 shows metrics for DC Circuit Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (DC Circuit in this case) being reported. Since these types of failures are directly linked to circuit exposure measured in Circuit Miles, this table provides a frequency calculation on a per 100 Circuit Miles (CM) basis.
- Table NERC 3.2-6 shows the metrics for DC Circuit Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other-Element Initiated), or by other facilities (Other Facility-Initiated).

**Table NERC 3.2-5
DC Circuit Momentary Outage Metrics - "Element-Initiated" Only**

Voltage Class	Circuit Miles	No. of Circuits	No. of Outages	Frequency (MCOF) (per 100 CM per yr)	Frequency (MOF) (per circuit per yr)
200-299 kV	NC	NC	C	C	C
400-499 kV	2920	10.0	1	0.0342	0.1000
500-599 kV	3368	7.0	9	0.2672	1.2857
All Voltages	6288	17	10	0.1590	0.5882

**Table NERC 3.2-6
DC Circuit Momentary Outage Metrics -
Other than "Element-Initiated"**

Voltage Class	No. of Circuits	No. of Outages	Frequency (MOF) (per circuit per yr)
200-299 kV	NC	C	C
400-499 kV	10.0	0	0.0000
500-599 kV	7.0	35	5.0000
All Voltages	17.0	35	2.0588

3.2.2.2 DC Circuit Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table NERC 3.2-7 reports Cause Code data for DC Circuit Momentary Outages.

**Table NERC 3.2-7
DC Circuit Momentary Outages by Cause Code**

Outage Cause Code	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	C	C	0	0.0%	0	0.0%	0	0.0%
Lightning	C	C	0	0.0%	1	2.3%	1	2.2%
Environmental	C	C	0	0.0%	0	0.0%	0	0.0%
Contamination	C	C	0	0.0%	1	2.3%	1	2.2%
Foreign Interference	C	C	0	0.0%	0	0.0%	0	0.0%
Fire	C	C	0	0.0%	0	0.0%	0	0.0%
Vandalism, Terrorism, or Malicious Acts	C	C	0	0.0%	0	0.0%	0	0.0%
Failed AC Substation Equipment	C	C	0	0.0%	0	0.0%	0	0.0%
Failed AC/DC Terminal Equipment	C	C	0	0.0%	0	0.0%	0	0.0%
Failed Protection System Equipment	C	C	0	0.0%	0	0.0%	0	0.0%
Failed AC Circuit Equipment	C	C	0	0.0%	0	0.0%	0	0.0%
Failed DC Circuit Equipment	C	C	0	0.0%	0	0.0%	0	0.0%
Vegetation	C	C	0	0.0%	0	0.0%	0	0.0%
Power System Condition	C	C	0	0.0%	34	77.3%	34	75.6%
Human Error	C	C	0	0.0%	0	0.0%	0	0.0%
Unknown	C	C	1	100.0%	8	18.2%	9	20.0%
Other	C	C	0	0.0%	0	0.0%	0	0.0%
TOTAL	C	C	1	100.0%	44	100.0%	45	100.0%

3.2.2.3 Other DC Circuit Momentary Outage Data

Table NERC 3.2-8 on the next page shows other DC Circuit Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table NERC 3.2-8
DC Circuit - Other Momentary Outage Attributes**

Fault Type	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	C	C	0	0.0%	35	79.5%	35	77.8%
P-P fault	C	C	0	0.0%	0	0.0%	0	0.0%
Single P-G fault	C	C	1	100.0%	0	0.0%	1	2.2%
P-P-G, 3 P, or 3P-G fault	C	C	0	0.0%	0	0.0%	0	0.0%
Unknown fault type	C	C	0	0.0%	9	20.5%	9	20.0%
TOTAL	C	C	1	100.0%	44	100.0%	45	100.0%

Outage Initiation Code	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	C	C	1	100.0%	9	20.5%	10	22.2%
Other Element-Initiated	C	C	0	0.0%	0	0.0%	0	0.0%
AC Substation-Initiated	C	C	0	0.0%	0	0.0%	0	0.0%
AC/DC Terminal-Initiated	C	C	0	0.0%	0	0.0%	0	0.0%
Other Facility-Initiated	C	C	0	0.0%	35	79.5%	35	77.8%
TOTAL	C	C	1	100.0%	44	100.0%	45	100.0%

Outage Mode Code	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	C	C	1	100.0%	44	100.0%	45	100.0%
Dependent Mode Initiating	C	C	0	0.0%	0	0.0%	0	0.0%
Dependent Mode	C	C	0	0.0%	0	0.0%	0	0.0%
Common Mode	C	C	0	0.0%	0	0.0%	0	0.0%
Common Mode Initiating	C	C	0	0.0%	0	0.0%	0	0.0%
TOTAL	C	C	1	100.0%	44	100.0%	45	100.0%

Event Type #	200-299 kV		400-499 kV		500-599 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
20	C	C	1	100.0%	44	100.0%	45	100.0%
40	C	C	0	0.0%	0	0.0%	0	0.0%
50	C	C	0	0.0%	0	0.0%	0	0.0%
TOTAL	C	C	1	100.0%	44	100.0%	45	100.0%

3.2.3 Total DC Circuit Metrics

Table NERC 3.2-9 on the next page displays DC Circuit metrics that are defined in Appendix 2.

**Table NERC 3.2-9
DC Circuit Metrics 1-16 per Appendix 2**

Voltage Class	OH/UG	Element Outage Frequency (1-3)			Element Outage Duration, Repair Time, and Update Time (4-7)						Element Availability (8-10)		
		TOF	SOF	MOF	SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
						P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	Overhead	C	C	C	C	C	C	C	C	C	C	C	C
400-499 kV	Overhead	1.13	1.00	0.13	3.69	3.49	3.69	3.89	2.13	8756.31	99.96	37.50	0.00
400-499 kV	Underground	C	C	C	C	C	C	C	C	C	C	C	C
500-599 kV	Overhead	4.50	3.00	1.50	3.34	1.10	1.11	1.12	0.43	2918.89	99.96	0.00	0.00

Voltage Class	OH/UG	Circuit Outage Frequency (11-13)						Multiple Circuit Outage Frequency (14-16)			Outage Totals		
		TCOF		SCOF		MCOF		TMCOF	SMCOF	MMCOF	Momentary Outages	Sustained Outages	Sustained Outages Hours
		All	Elemnt. Init.	All	Elemnt. Init.	All	Elemnt. Init.						
200-299 kV	Overhead	C	C	C	C	C	C	C	C	C	C	C	C
400-499 kV	Overhead	0.31	0.17	0.27	0.14	0.03	0.03	0.00	0.00	0.00	1	8	29.6
400-499 kV	Underground	C	C	C	C	C	C				C	C	C
500-599 kV	Overhead	0.82	0.39	0.55	0.12	0.27	0.27	0.00	0.00	0.00	9	18	20.1
TOTAL											10	26	49.6

3.3 Transformer Metrics and Data

Transformer metrics are displayed in three sections: Section 3.3.1 addresses Sustained Outages, Section 3.3.2 addresses Momentary Outages, and Section 3.3.3 has Transformer metrics per the formulas in Appendix 2. Data and metrics are displayed for all four Transformer Voltages Classes in the NERC template plus the total of all Voltage Classes.

3.3.1 Transformer Sustained Outages

3.3.1.1 Transformer Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.3-1 shows metrics for Transformer Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (Transformer in this case) being reported.
- Table NERC 3.3-2 shows the metrics for Transformer Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

Table NERC 3.3-1
Transformer Sustained Outage Metrics - "Element-Initiated" Only

Voltage Class	No. of Transformers	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per transformer per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	32.0	3	185.0	0.0938	61.7
300-399 kV	164.9	9	13200.5	0.0546	1466.7
400-599 kV	415.7	15	7853.2	0.0361	523.5
600-799 kV	93.0	3	8473.4	0.0323	2824.5
All Voltages	705.6	30	29712.1	0.0425	990.4

Table NERC 3.3-2
Transformer Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Transformers	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per transformer per yr)	MTTR or Mean Outage Duration (hr)
200-299 kV	32.0	2	6.3	0.0625	3.1
300-399 kV	164.9	19	9256.3	0.1152	487.2
400-599 kV	415.7	31	1548.1	0.0746	49.9
600-799 kV	93.0	18	4339.3	0.1935	241.1
All Voltages	705.6	70	15149.9	0.0992	216.4

3.3.1.2 Transformer Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table NERC 3.3-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table NERC 3.3-3 (p. 1 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	200-299kV						300-399kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	0	0.0%	0	0.0%	0.0	0.0%	6	21.4%	5	17.9%	39.7	0.2%
Lightning	1	20.0%	1	20.0%	0.4	0.2%	2	7.1%	2	7.1%	4.3	0.0%
Environmental	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	0	0.0%	0	0.0%	0.0	0.0%	2	7.1%	2	7.1%	0.1	0.0%
Foreign Interference	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	2	40.0%	2	40.0%	6.3	3.3%	9	32.1%	9	32.1%	14650.2	65.2%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	2	40.0%	2	40.0%	184.6	96.5%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	1	3.6%	7752.0	34.5%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	0	0.0%	0	0.0%	0.0	0.0%	1	3.6%	1	3.6%	1.0	0.0%
Human Error	0	0.0%	0	0.0%	0.0	0.0%	3	10.7%	2	7.1%	3.2	0.0%
Unknown	0	0.0%	0	0.0%	0.0	0.0%	5	17.9%	5	17.9%	5.9	0.0%
Other	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	1	3.6%	0.4	0.0%
TOTAL	5	100.0%	5	100.0%	191.3	100.0%	28	100.0%	28	100.0%	22456.7	100.0%

Table NERC 3.3-3 (p. 2 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	400-599kV						600-799kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Lightning	1	2.2%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Environmental	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	1	2.2%	1	2.2%	3.1	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	4	8.7%	4	8.7%	25.1	0.3%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	1	2.2%	416.5	4.4%	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	16	34.8%	15	32.6%	8747.1	93.0%	7	33.3%	8	38.1%	12608.7	98.4%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	4	8.7%	5	10.9%	8.3	0.1%	9	42.9%	9	42.9%	178.7	1.4%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	1	4.8%	0	0.0%	0.0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	4	8.7%	4	8.7%	5.7	0.1%	1	4.8%	1	4.8%	1.0	0.0%
Human Error	10	21.7%	10	21.7%	156.9	1.7%	2	9.5%	2	9.5%	23.1	0.2%
Unknown	3	6.5%	3	6.5%	10.6	0.1%	0	0.0%	0	0.0%	0.0	0.0%
Other	3	6.5%	3	6.5%	28.0	0.3%	1	4.8%	1	4.8%	1.1	0.0%
TOTAL	46	100.0%	46	100.0%	9401.3	100.0%	21	100.0%	21	100.0%	12812.7	100.0%

Table NERC 3.3-3 (p. 3 of 3)
Transformer Sustained Outages by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	6	6.0%	5	5.0%	39.7	0.1%
Lightning	4	4.0%	3	3.0%	4.7	0.0%
Environmental	0	0.0%	0	0.0%	0.0	0.0%
Contamination	3	3.0%	3	3.0%	3.2	0.0%
Foreign Interference	4	4.0%	4	4.0%	25.1	0.1%
Fire	0	0.0%	1	1.0%	416.5	0.9%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	34	34.0%	34	34.0%	36012.3	80.3%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0.0	0.0%
Failed Protection System Equipment	15	15.0%	16	16.0%	371.6	0.8%
Failed AC Circuit Equipment	1	1.0%	1	1.0%	7752.0	17.3%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	6	6.0%	6	6.0%	7.6	0.0%
Human Error	15	15.0%	14	14.0%	183.3	0.4%
Unknown	8	8.0%	8	8.0%	16.5	0.0%
Other	4	4.0%	5	5.0%	29.5	0.1%
TOTAL	100	100.0%	100	100.0%	44862.0	100.0%

3.3.1.3 Other Transformer Sustained Outage Data

Table NERC 3.3-4 on the next page shows other Transformer Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, Event Type, and Outage Duration Interval.

Table NERC 3.3-4 (p. 1 of 3)
Transformer - Other Sustained Outage Attributes

Fault Type	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	4	80.0%	190.9	99.8%	21	75.0%	58.7	0.3%	37	80.4%	2158.2	23.0%	17	81.0%	4293.7	33.5%
P-P fault	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	1	4.8%	46.4	0.4%
Single P-G fault	0	0.0%	0.0	0.0%	3	10.7%	5839.3	26.0%	5	10.9%	7142.6	76.0%	2	9.5%	8471.5	66.1%
P-P-G, 3 P, or 3P-G fault	0	0.0%	0.0	0.0%	4	14.3%	16558.7	73.7%	1	2.2%	24.2	0.3%	0	0.0%	0.0	0.0%
Unknown fault type	1	20.0%	0.4	0.2%	0	0.0%	0.0	0.0%	3	6.5%	76.2	0.8%	1	4.8%	1.1	0.0%
TOTAL	5	100.0%	191.3	100.0%	28	100.0%	22456.7	100.0%	46	100.0%	9401.3	100.0%	21	100.0%	12812.7	100.0%

Outage Initiation Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	3	60.0%	185.0	96.7%	9	32.1%	13200.5	58.8%	15	32.6%	7853.2	83.5%	3	14.3%	8473.4	66.1%
Other Element-Initiated	0	0.0%	0.0	0.0%	13	46.4%	32.8	0.1%	7	15.2%	24.9	0.3%	1	4.8%	1.1	0.0%
AC Substation-Initiated	2	40.0%	6.3	3.3%	4	14.3%	9221.7	41.1%	13	28.3%	1506.7	16.0%	5	23.8%	4079.1	31.8%
AC/DC Terminal-Initiated	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
Other Facility-Initiated	0	0.0%	0.0	0.0%	2	7.1%	1.8	0.0%	11	23.9%	16.5	0.2%	12	57.1%	259.0	2.0%
TOTAL	5	100.0%	191.3	100.0%	28	100.0%	22456.7	100.0%	46	100.0%	9401.3	100.0%	21	100.0%	12812.7	100.0%

Outage Mode Code	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	1	20.0%	0.4	0.2%	12	42.9%	8268.1	36.8%	22	47.8%	3692.4	39.3%	12	57.1%	8680.7	67.8%
Dependent Mode Initiating	2	40.0%	184.6	96.5%	0	0.0%	0.0	0.0%	7	15.2%	5240.6	55.7%	6	28.6%	3499.3	27.3%
Dependent Mode	0	0.0%	0.0	0.0%	16	57.1%	14188.7	63.2%	12	26.1%	107.9	1.1%	1	4.8%	584.5	4.6%
Common Mode	2	40.0%	6.3	3.3%	0	0.0%	0.0	0.0%	5	10.9%	360.4	3.8%	2	9.5%	48.2	0.4%
Common Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	5	100.0%	191.3	100.0%	28	100.0%	22456.7	100.0%	46	100.0%	9401.3	100.0%	21	100.0%	12812.7	100.0%

Table NERC 3.3-4 (p. 2 of 3)
Transformer - Other Sustained Outage Attributes

Event Type #	200-299 kV				300-399 kV				400-599 kV				600-799 kV			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
10	1	20.0%	0.4	0.2%	8	28.6%	16977.7	75.6%	15	32.6%	3311.1	35.2%	4	19.0%	11936.5	93.2%
50	4	80.0%	190.9	99.8%	19	67.9%	5461.1	24.3%	31	67.4%	6090.2	64.8%	17	81.0%	876.2	6.8%
TOTAL	5	100.0%	191.3	100.0%	28	100.0%	22456.7	100.0%	46	100.0%	9401.3	100.0%	21	100.0%	12812.7	100.0%

Transformer - Sustained Outage Duration Intervals

Outage Duration Interval	200-299 kV		300-399 kV		400-599 kV		600-799 kV	
	No. Sust.	%	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	0	0.0%	7	25.0%	7	15.2%	0	0.0%
6-10 Minutes	0	0.0%	0	0.0%	3	6.5%	1	4.8%
11-30 Minutes	1	20.0%	3	10.7%	4	8.7%	3	14.3%
31-120 Minutes	0	0.0%	5	17.9%	6	13.0%	3	14.3%
121 Minutes to 24 Hours	3	60.0%	9	32.1%	11	23.9%	7	33.3%
> 24 Hours to 48 Hours	0	0.0%	0	0.0%	4	8.7%	2	9.5%
> 48 Hours	1	20.0%	4	14.3%	11	23.9%	5	23.8%
TOTAL	5	100.0%	28	100.0%	46	100.0%	21	100.0%

Table NERC 3.3-4 (p. 3 of 3)
Transformer - Other Sustained Outage Attributes

Fault Type	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
No fault	79	79.0%	6701.5	14.9%
P-P fault	1	1.0%	46.4	0.1%
Single P-G fault	10	10.0%	21453.4	47.8%
P-P-G, 3 P, or 3P-G fault	5	5.0%	16582.9	37.0%
Unknown fault type	5	5.0%	77.8	0.2%
TOTAL	100	100.0%	44862.0	100.0%

Outage Initiation Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	30	30.0%	29712.1	66.2%
Other Element-Initiated	21	21.0%	58.8	0.1%
AC Substation-Initiated	24	24.0%	14813.8	33.0%
AC/DC Terminal-Initiated	0	0.0%	0.0	0.0%
Other Facility-Initiated	25	25.0%	277.3	0.6%
TOTAL	100	100.0%	44862.0	100.0%

Outage Mode Code	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
Single Mode	47	47.0%	20641.5	46.0%
Dependent Mode Initiating	15	15.0%	8924.6	19.9%
Dependent Mode	29	29.0%	14881.1	33.2%
Common Mode	9	9.0%	414.8	0.9%
Common Mode Initiating	0	0.0%	0.0	0.0%
TOTAL	100	100.0%	44862.0	100.0%

Event Type #	All Voltages			
	No. Sust.	%	No. Hrs.	Hours %
10	28	28.0%	32225.6	71.8%
50	71	71.0%	12618.4	28.1%
TOTAL	100	100.0%	44862.0	100.0%

Outage Duration Interval	All Voltages	
	No. Sust.	%
1-5 Minutes	14	14.0%
6-10 Minutes	4	4.0%
11-30 Minutes	11	11.0%
31-120 Minutes	14	14.0%
121 Minutes to 24 Hours	30	30.0%
> 24 Hours to 48 Hours	6	6.0%
> 48 Hours	21	21.0%
TOTAL	100	100.0%

3.3.2 Transformer Momentary Outages

3.3.2.1 Transformer Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.3-5 shows metrics for Transformer Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (Transformer in this case) being reported.
- Table NERC 3.3-6 shows the metrics for Transformer Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

**Table NERC 3.3-5
Transformer Momentary Outage Metrics -
"Element-Initiated" Only**

Voltage Class	No. of Transformers	No. of Outages	Frequency (MOF) (per transformer per yr)
200-299 kV	32.0	1	0.0313
300-399 kV	164.9	0	0.0000
400-599 kV	415.7	0	0.0000
600-799 kV	93.0	2	0.0215
All Voltages	705.6	3	0.0043

**Table NERC 3.3-6
Transformer Momentary Outage Metrics -
Other than "Element-Initiated"**

Voltage Class	No. of Transformers	No. of Outages	Frequency (MOF) (per transformer per yr)
200-299 kV	32.0	1	0.0313
300-399 kV	164.9	26	0.1577
400-599 kV	415.7	7	0.0168
600-799 kV	93.0	2	0.0215
All Voltages	705.6	36	0.0510

3.3.2.2 Transformer Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table NERC 3.3-7 on the next page reports Cause Code data for Transformer Momentary Outages.

**Table NERC 3.3-7
Transformer Momentary Outages by Cause Code**

Outage Cause Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	0	0.0%	10	38.5%	0	0.0%	2	50.0%	12	30.8%
Lightning	2	100.0%	8	30.8%	2	28.6%	0	0.0%	12	30.8%
Environmental	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Contamination	0	0.0%	8	30.8%	0	0.0%	0	0.0%	8	20.5%
Foreign Interference	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fire	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed AC Substation Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed AC/DC Terminal Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed Protection System Equipment	0	0.0%	0	0.0%	0	0.0%	2	50.0%	2	5.1%
Failed AC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Vegetation	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Power System Condition	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Human Error	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Unknown	0	0.0%	0	0.0%	1	14.3%	0	0.0%	1	2.6%
Other	0	0.0%	0	0.0%	4	57.1%	0	0.0%	4	10.3%
TOTAL	2	100.0%	26	100.0%	7	100.0%	4	100.0%	39	100.0%

3.3.2.3 Other Transformer Momentary Outage Data

Table NERC 3.3-8 on the next page shows other Transformer Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table NERC 3.3-8
Transformer - Other Momentary Outage Attributes**

Fault Type	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	1	50.0%	26	100.0%	7	100.0%	0	0.0%	34	87.2%
P-P fault	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Single P-G fault	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
P-P-G, 3 P, or 3P-G fault	0	0.0%	0	0.0%	0	0.0%	4	100.0%	4	10.3%
Unknown fault type	1	50.0%	0	0.0%	0	0.0%	0	0.0%	1	2.6%
TOTAL	2	100.0%	26	100.0%	7	100.0%	4	100.0%	39	100.0%

Outage Initiation Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	1	50.0%	0	0.0%	0	0.0%	2	50.0%	3	7.7%
Other Element-Initiated	1	50.0%	26	100.0%	7	100.0%	0	0.0%	34	87.2%
AC Substation-Initiated	0	0.0%	0	0.0%	0	0.0%	2	50.0%	2	5.1%
AC/DC Terminal-Initiated	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other Facility-Initiated	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
TOTAL	2	100.0%	26	100.0%	7	100.0%	4	100.0%	39	100.0%

Outage Mode Code	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	1	50.0%	0	0.0%	0	0.0%	4	100.0%	5	12.8%
Dependent Mode Initiating	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Dependent Mode	1	50.0%	26	100.0%	7	100.0%	0	0.0%	34	87.2%
Common Mode	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Common Mode Initiating	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
TOTAL	2	100.0%	26	100.0%	7	100.0%	4	100.0%	39	100.0%

Event Type #	200-299 kV		300-399 kV		400-599 kV		600-799 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%	No. Mom.	%
10	1	50.0%	0	0.0%	0	0.0%	2	50.0%	3	7.7%
50	1	50.0%	26	100.0%	7	100.0%	2	50.0%	36	92.3%
TOTAL	2	100.0%	26	100.0%	7	100.0%	4	100.0%	39	100.0%

3.3.3 Total Transformer Metrics

Table NERC 3.3-9 displays Transformer metrics that are defined in Appendix 2.

**Table NERC 3.3-9
Transformer Metrics 1-10 per Appendix 2***

Voltage Class	Element Outage Frequency (1-3)			Element Outage Duration, Repair Time, and Update Time (4-7)						Element Availability (8-10)		
	TOF	SOF	MOF	SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
					P(5%) <	MTTR 50/50	P(5%) >					
200-299 kV	0.22	0.16	0.06	5.98	28.97	38.26	47.55	3.50	56025.74	99.93	121.88	0.00
300-399 kV	0.33	0.17	0.16	136.18	796.56	802.03	807.49	1.80	50788.12	98.42	84.12	0.00
400-599 kV	0.13	0.11	0.02	22.62	203.75	204.38	205.00	2.89	78959.36	99.74	88.10	1.89
600-799 kV	0.27	0.23	0.04	137.77	601.72	610.13	618.53	5.10	38184.16	98.40	81.72	0.00

*Note: Metrics 11-16 only apply to AC Circuits or DC Circuits

Voltage Class	Outage Totals		
	Momentary Outages	Sustained Outages	Sustained Outages Hours
200-299 kV	2	5	191.3
300-399 kV	26	28	22456.7
400-599 kV	7	46	9401.3
600-799 kV	4	21	12812.7
TOTAL	39	100	44862.0

3.4 AC/DC BTB Converter Metrics and Data

AC/DC BTB Converter metrics are displayed in three sections: Section 3.4.1 addresses Sustained Outages, Section 3.4.2 addresses Momentary Outages, and Section 3.4.3 has AC/DC BTB Converter metrics per the formulas in Appendix 2. Data and metrics are displayed for the two AC/DC BTB Converter Voltages Classes in the NERC template plus the total of all Voltage Classes.

3.4.1 AC/DC BTB Converter Sustained Outages

3.4.1.1 AC/DC BTB Converter Sustained Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.4-1 shows metrics for AC/DC BTB Converter Sustained Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC/DC BTB Converter in this case) being reported.
- Table NERC 3.4-2 shows the metrics for AC/DC BTB Converter Sustained Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

Table NERC 3.4-1

AC/DC BTB Converter Sustained Outage Metrics - "Element-Initiated" Only

Voltage Class	No. of Converters	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per converter per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	7.0	15	49.8	2.1429	3.3
300-399 kV	7.0	2	3.2	0.2857	1.6
All Voltages	14.0	17	53.0	1.2143	3.1

Table NERC 3.4-2

AC/DC BTB Converter Sustained Outage Metrics - Other than "Element-Initiated"

Voltage Class	No. of Converters	No. of Outages	Total Outage Time (hr)	Frequency (SOF) (per converter per yr)	MTR or Mean Outage Duration (hr)
200-299 kV	7.0	22	59.8	3.1429	2.7
300-399 kV	7.0	18	65.9	2.5714	3.7
All Voltages	14.0	40	125.7	2.8571	3.1

3.4.1.2 AC/DC BTB Converter Sustained Outage Cause Code Data

For Sustained Outages, TADS requests two Cause Codes – an Initiating Cause Code that describes the initiating cause and a Sustained Cause Code that describes the cause that contributes to the longest duration. Table NERC 3.4-3 shows the two Outage Cause Codes (Initiating and Sustained) plus the number of outage hours associated with each Cause Code.

Table NERC 3.4-3 (p 1 of 2)
AC/DC BTB Converter Sustained Outages by Cause Code

Outage Cause Code	200-299kV						300-399kV					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	4	10.8%	2	5.4%	7.4	6.7%	0	0.0%	0	0.0%	0.0	0.0%
Lightning	0	0.0%	0	0.0%	0.0	0.0%	1	5.0%	0	0.0%	0.0	0.0%
Environmental	1	2.7%	1	2.7%	0.7	0.7%	0	0.0%	0	0.0%	0.0	0.0%
Contamination	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	2	5.4%	2	5.4%	3.0	2.8%	0	0.0%	0	0.0%	0.0	0.0%
Fire	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	3	8.1%	4	10.8%	19.6	17.9%	3	15.0%	3	15.0%	48.9	70.8%
Failed AC/DC Terminal Equipment	8	21.6%	6	16.2%	20.5	18.7%	3	15.0%	5	25.0%	3.9	5.6%
Failed Protection System Equipment	0	0.0%	0	0.0%	0.0	0.0%	2	10.0%	4	20.0%	6.7	9.7%
Failed AC Circuit Equipment	10	27.0%	9	24.3%	44.9	41.0%	0	0.0%	0	0.0%	0.0	0.0%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	3	8.1%	0	0.0%	0.0	0.0%	0	0.0%	0	0.0%	0.0	0.0%
Human Error	2	5.4%	0	0.0%	0.0	0.0%	6	30.0%	6	30.0%	5.8	8.4%
Unknown	3	8.1%	12	32.4%	13.3	12.2%	4	20.0%	2	10.0%	3.9	5.6%
Other	1	2.7%	1	2.7%	0.2	0.1%	1	5.0%	0	0.0%	0.0	0.0%
TOTAL	37	100.0%	37	100.0%	109.6	100.0%	20	100.0%	20	100.0%	69.1	100.0%

Table NERC 3.4-3 (p 2 of 2)
AC/DC BTB Converter Sustained Outages
by Cause Code

Outage Cause Code	All Voltages					
	No. Init.	Init. %	No. Sust.	Sust. %	No. Hrs.	Hours %
Weather, excluding lightning	4	7.0%	2	3.5%	7.4	4.1%
Lightning	1	1.8%	0	0.0%	0.0	0.0%
Environmental	1	1.8%	1	1.8%	0.7	0.4%
Contamination	0	0.0%	0	0.0%	0.0	0.0%
Foreign Interference	2	3.5%	2	3.5%	3.0	1.7%
Fire	0	0.0%	0	0.0%	0.0	0.0%
Vandalism, Terrorism, or Malicious Acts	0	0.0%	0	0.0%	0.0	0.0%
Failed AC Substation Equipment	6	10.5%	7	12.3%	68.5	38.3%
Failed AC/DC Terminal Equipment	11	19.3%	11	19.3%	24.4	13.6%
Failed Protection System Equipment	2	3.5%	4	7.0%	6.7	3.7%
Failed AC Circuit Equipment	10	17.5%	9	15.8%	44.9	25.1%
Failed DC Circuit Equipment	0	0.0%	0	0.0%	0.0	0.0%
Vegetation	0	0.0%	0	0.0%	0.0	0.0%
Power System Condition	3	5.3%	0	0.0%	0.0	0.0%
Human Error	8	14.0%	6	10.5%	5.8	3.2%
Unknown	7	12.3%	14	24.6%	17.2	9.6%
Other	2	3.5%	1	1.8%	0.2	0.1%
TOTAL	57	100.0%	57	100.0%	178.7	100.0%

3.4.1.3 Other AC/DC BTB Converter Sustained Outage Data

Table NERC 3.4-4 on the next page shows other AC/DC BTB Converter Sustained Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, Event Type, and Outage Duration Interval.

**Table NERC 3.4-4
AC/DC BTB Converter - Other Sustained Outage Attributes**

Fault Type	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
No fault	31	83.8%	96.0	87.6%	15	75.0%	19.6	28.3%	46	80.7%	115.5	64.7%
P-P fault	0	0.0%	0.0	0.0%	1	5.0%	1.8	2.6%	1	1.8%	1.8	1.0%
Single P-G fault	3	8.1%	4.4	4.0%	4	20.0%	47.7	69.1%	7	12.3%	52.1	29.2%
P-P-G, 3 P, or 3P-G fault	3	8.1%	9.2	8.4%	0	0.0%	0.0	0.0%	3	5.3%	9.2	5.1%
Unknown fault type	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	37	100.0%	109.6	100.0%	20	100.0%	69.1	100.0%	57	100.0%	178.7	100.0%

Outage Initiation Code	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Element-Initiated	15	40.5%	49.8	45.4%	2	10.0%	3.2	4.6%	17	29.8%	53.0	29.6%
Other Element-Initiated	3	8.1%	7.5	6.8%	0	0.0%	0.0	0.0%	3	5.3%	7.5	4.2%
AC Substation-Initiated	5	13.5%	26.3	24.0%	6	30.0%	53.9	78.0%	11	19.3%	80.2	44.9%
AC/DC Terminal-Initiated	11	29.7%	25.8	23.5%	1	5.0%	0.0	0.0%	12	21.1%	25.8	14.4%
Other Facility-Initiated	3	8.1%	0.3	0.2%	11	55.0%	12.0	17.3%	14	24.6%	12.2	6.8%
TOTAL	37	100.0%	109.6	100.0%	20	100.0%	69.1	100.0%	57	100.0%	178.7	100.0%

Outage Mode Code	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
Single Mode	24	64.9%	68.2	62.2%	13	65.0%	62.3	90.1%	37	64.9%	130.5	73.0%
Dependent Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
Dependent Mode	6	16.2%	30.7	28.0%	7	35.0%	6.8	9.9%	13	22.8%	37.5	21.0%
Common Mode	7	18.9%	10.7	9.8%	0	0.0%	0.0	0.0%	7	12.3%	10.7	6.0%
Common Mode Initiating	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%	0	0.0%	0.0	0.0%
TOTAL	37	100.0%	109.6	100.0%	20	100.0%	69.1	100.0%	57	100.0%	178.7	100.0%

Event Type #	200-299 kV				300-399 kV				All Voltages			
	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %	No. Sust.	%	No. Hrs.	Hours %
50	37	100.0%	109.6	100.0%	20	100.0%	69.1	100.0%	57	100.0%	178.7	100.0%
TOTAL	37	100.0%	109.6	100.0%	20	100.0%	69.1	100.0%	57	100.0%	178.7	100.0%

Table NERC 3.4-4 (continued on next page)

Table NERC 3.4-4 (continued)
AC/DC BTB Converter
Sustained Outage Duration Intervals

Outage Duration Interval	200-299 kV		300-399 kV		All Voltages	
	No. Sust.	%	No. Sust.	%	No. Sust.	%
1-5 Minutes	4	10.8%	3	15.0%	7	12.3%
6-10 Minutes	3	8.1%	3	15.0%	6	10.5%
11-30 Minutes	2	5.4%	3	15.0%	5	8.8%
31-120 Minutes	12	32.4%	7	35.0%	19	33.3%
121 Minutes to 24 Hours	16	43.2%	3	15.0%	19	33.3%
> 24 Hours to 48 Hours	0	0.0%	1	5.0%	1	1.8%
> 48 Hours	0	0.0%	0	0.0%	0	0.0%
TOTAL	37	100.0%	20	100.0%	57	100.0%

3.4.2 AC/DC BTB Converter Momentary Outages

3.4.2.1 AC/DC BTB Converter Momentary Outage Initiation Code Metrics

The Outage Initiation Code describes where an outage initiated.

- Table NERC 3.4-5 shows metrics for AC/DC BTB Converter Momentary Outages that were “Element-Initiated,” which means the outages were initiated on or within the Element (AC/DC BTB Converter in this case) being reported.
- Table NERC 3.4-6 shows the metrics for AC/DC BTB Converter Momentary Outages that were initiated by all other Outage Initiation Codes *except* those that were Element-Initiated. These included outages that were initiated on or within an AC Substation, an AC/DC Terminal, another TADS Element (Other Element-Initiated), or by other facilities (Other Facility-Initiated).

**Table NERC 3.4-5
AC/DC BTB Converter Momentary Outage
Metrics - "Element-Initiated" Only**

Voltage Class	No. of Converters	No. of Outages	Frequency (MOF) (per converter per yr)
200-299 kV	7.0	0	0.0000
300-399 kV	7.0	0	0.0000
All Voltages	14.0	0	0.0000

**Table NERC 3.4-6
AC/DC BTB Converter Momentary Outage
Metrics - Other than "Element-Initiated"**

Voltage Class	No. of Converters	No. of Outages	Frequency (MOF) (per converter per yr)
200-299 kV	7.0	0	0.0000
300-399 kV	7.0	0	0.0000
All Voltages	14.0	0	0.0000

3.4.2.2 AC/DC BTB Converter Momentary Outage Cause Code Data

For Momentary Outages, TADS requests one Cause Code: an Initiating Cause Code. Table NERC 3.4-7 on the next page reports Cause Code data for AC/DC BTB Converter Momentary Outages.

**Table NERC 3.4-7
AC/DC BTB Converter Momentary Outages
by Cause Code**

Outage Cause Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Weather, excluding lightning	0	~	0	~	0	~
Lightning	0	~	0	~	0	~
Environmental	0	~	0	~	0	~
Contamination	0	~	0	~	0	~
Foreign Interference	0	~	0	~	0	~
Fire	0	~	0	~	0	~
Vandalism, Terrorism, or Malicious Acts	0	~	0	~	0	~
Failed AC Substation Equipment	0	~	0	~	0	~
Failed AC/DC Terminal Equipment	0	~	0	~	0	~
Failed Protection System Equipment	0	~	0	~	0	~
Failed AC Circuit Equipment	0	~	0	~	0	~
Failed DC Circuit Equipment	0	~	0	~	0	~
Vegetation	0	~	0	~	0	~
Power System Condition	0	~	0	~	0	~
Human Error	0	~	0	~	0	~
Unknown	0	~	0	~	0	~
Other	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

3.4.2.3 Other AC/DC BTB Converter Momentary Outage Data

Table NERC 3.4-8 shows other AC/DC BTB Converter Momentary Outage attributes by Fault Type, Outage Initiation Code, Outage Mode Code, and Event Type.

**Table NERC 3.4-8
AC/DC BTB Converter
Other Momentary Outage Attributes**

Fault Type	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
No fault	0	~	0	~	0	~
P-P fault	0	~	0	~	0	~
Single P-G fault	0	~	0	~	0	~
P-P-G, 3 P, or 3P-G fault	0	~	0	~	0	~
Unknown fault type	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Outage Initiation Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Element-Initiated	0	~	0	~	0	~
Other Element-Initiated	0	~	0	~	0	~
AC Substation-Initiated	0	~	0	~	0	~
AC/DC Terminal-Initiated	0	~	0	~	0	~
Other Facility-Initiated	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Outage Mode Code	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	%	No. Mom.	%	No. Mom.	%
Single Mode	0	~	0	~	0	~
Dependent Mode Initiating	0	~	0	~	0	~
Dependent Mode	0	~	0	~	0	~
Common Mode	0	~	0	~	0	~
Common Mode Initiating	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

Event Type #	200-299 kV		300-399 kV		All Voltages	
	No. Mom.	0	No. Mom.	0	No. Mom.	%
50	0	~	0	~	0	~
TOTAL	0	~	0	~	0	~

3.4.3 Total AC/DC BTB Converter Metrics

Table NERC 3.4-9 on the next page displays AC/DC BTB Converter metrics which are defined in Appendix 2.

**Table NERC 3.4-9
AC/DC BTB Converter Metrics 1-10 per Appendix 2***

Voltage Class	Element Outage Frequency (1-3)			Element Outage Duration, Repair Time, and Update Time (4-7)						Element Availability (8-10)		
	TOF	SOF	MOF	SODT	MTRR	MTRR	MTRR	MdTTR	MTBF	APC %	PCZO %	PCDR %
					P(5%) <	MTRR 50/50	P(5%) >					
200-299 kV	5.29	5.29	0.00	15.66	2.96	2.96	2.97	1.55	1654.33	99.82	14.29	0.00
300-399 kV	2.86	2.86	0.00	9.87	3.41	3.45	3.50	0.89	3062.55	99.89	28.57	0.00

***Note: Metrics 11-16 only apply to AC Circuits or DC Circuits**

Voltage Class	Outage Totals		
	Momentary Outages	Sustained Outages	Sustained Outages Hours
200-299 kV	0	37	109.6
300-399 kV	0	20	69.1
TOTAL	0	57	178.7

Appendix 1 TADS Definitions

The definitions are a separate document that may be downloaded at [http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_\(All\).pdf](http://www.nerc.com/docs/pc/tadstf/Appendix_1_TADS_2008_Reports_(All).pdf). These definitions were posted on September 11, 2008 for use during calendar year 2009 data collection.

Appendix 2 Metric Definitions

The TADS Metric definitions are contained on the table below, which is divided into two sections: the first page has metrics 1-10 that apply to *all* Elements. The second page has metrics 11-16 that only apply to AC Circuits or DC Circuits.

- Metric 5: Mean-time-to-repair (MTTR) has the same meaning as mean outage duration. Since this calculation may be based upon a limited number of outages for smaller Regions or individual Transmission Owner organizations, the computed value is an *estimate* of the “true” MTTR for the Element. Using statistical methods, one can estimate the uncertainty in the mean calculation. The tables in the main report provide a range of MTTR values:
 - The value that is calculated straight from the data is labeled “MTTR 50/50.”
 - The MTTR labeled “P(5%) >” means the true MTTR has a 5 % chance of being greater than this value, and the MTTR labeled “P(5%)<” means the true MTTR has a 5% chance of being lower than this value

When a fairly large number of outages are used to calculate the MTTR 50/50 value, the range of uncertainty is fairly low. See the Overhead AC Circuit MTTR values on NERC 3.1-9. When only a few outages are used, the range is very large, indicating a high degree of uncertainty between the calculated MTTR and the “true” MTTR.

- Metrics 11, 12, and 13: Circuit outage frequency on a per 100 Circuit Mile basis - Total Circuit Outage Frequency (TCOF), Sustained Circuit Outage Frequency (SCOF), and Momentary Circuit Outage Frequency (MCOF), are calculated twice – one calculation includes *all* outages while a second calculation only includes Element-Initiated outages. The second calculation more correctly relates outages initiated on the circuit (the Element in this case) to total circuit exposure measured by mileage.

No.	Metric	Formula	Units	Acronym
<i>Element Outage Frequency</i>				
1	Element Total Automatic Outage Frequency	Total Automatic Outages / Total Elements	No. Automatic Outages per Element per year	TOF
2	Element Sustained Outage Frequency	Total Sustained Outages / Total Elements	No. Sustained Outages per Element per year	SOF
3	Element Momentary Outage Frequency	Total Momentary Outages / Total Elements	No. Momentary Outages per Element per year	MOF
<i>Element Outage Duration, Repair Time, and Up Time</i>				
4	Element Sustained Outage Duration Time	Total Sustained Outage Hours / Total Elements	No. Sustained Outages hours per Element per year	SODT
5	Element Sustained Outage Mean Time to Repair. Also referred to as Mean Outage Duration	Total Sustained Outage Hours / Total Sustained Element Outages	Average no. of Sustained Outage Hours per outaged Element	MTTR
6	Median Time to Repair Sustained Element Outage Failures	The time when 50% of the Sustained Outage Duration hours per outaged Element are greater than this figure	Median no. of Sustained Outage Hours per outaged Element	MdTTR
7	Mean Time Between Sustained Element Outages (Mean "Up Time"). Also referred to as Mean Time Between Failures.	(Total Element Hours - Total Sustained Outage Hours) / Total Sustained Element Outages	Mean (average) no. of hours of operation of an Element before it fails	MTBF ¹
<i>Element Availability</i>				
8	Element Availability Percentage	1- (Total Sustained Outage Hours / Total Element Hours) * 100	Percentage	APC ¹
9	Percentage of Elements with Zero Automatic Outages	Total Elements with Zero Automatic Outages / Total Elements	Percentage	PCZO
10	Percent of Element Automatic Outages associated with a Disturbance Report (EOP-004)	Total Automatic Outages associated with a Disturbance Report / Total Automatic Outages	Percentage	PCDR

1 Since Non-Automatic Outage data are not collected, these metrics will be overstated from industry definitions.

	Metric	Formula	Units	Acronym
<i>Circuit Outage Frequency, per 100 Circuit Miles (Applies to AC and DC Circuits Only)</i>				
11	Circuit Total Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Automatic Outages} * 100) / \text{Total Circuit Miles}$	No. Automatic Outages per 100 Circuit Miles per year	TCOF _{100CM}
12	Circuit Sustained Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Sustained Outages} * 100) / \text{Total Circuit Miles}$	No. Sustained Outages per 100 Circuit Miles per year	SCOF _{100CM}
13	Circuit Momentary Outage Frequency, Mileage Adjusted	$(\text{Total Circuit Momentary Outages} * 100) / \text{Total Circuit Miles}$	No. Momentary Outages per 100 Circuit Miles per year	MCOF _{100CM}
<i>Multiple Circuit Outage Frequency per 100 Multi-Circuit Structure Miles (For AC Circuits, multi circuit outages are Event Type 30 outages; for DC Circuits, they are Event Type 40 outages.)</i>				
14	Multi Circuit Total Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Automatic Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Automatic Outages per 100 Multi-Circuit Structures Miles per year	TMCOF _{100SM}
15	Multi-Circuit Sustained Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Sustained Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Sustained Outages per 100 Multi-Circuit Structure Miles per year	SMCOF _{100SM}
16	Multi-Circuit Momentary Outage Frequency, Mileage Adjusted	$(\text{Total Multi-Circuit Momentary Outages} * 100) / \text{Total Multi-Circuit Structure Miles}$	No. Momentary Outages per 100 Multi-Circuit Structure Miles per year	MMCOF _{100SM}

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