***** THIS STANDARD REPLACES FORMER TDMIS-29 *****

2700. GENERAL

Short circuits, the uncontrolled flow of electricity from energized conductors or equipment to a neutral or ground, occur in power systems when insulation fails or is bypassed due to; system overvoltages caused by lightning, switching surges, insulation contamination, mechanical failures, conductive materials crossing conductors, or other natural causes. These are also referred to as "faults" and the current flow is referred to as "fault current". The number of short circuits and the magnitude of the current flow can be minimized with proper design, operation, and maintenance of overhead distribution systems.

2701. FUSE RATING

Type K expulsion fuse links (Item FK), per ANSI C37.42, are the standard fuse links for use in open type fuse cutouts on the DOP system. K link fuses provide improved coordination with station equipment and a greater range of coordination between fuses. Type T expulsion fuse links (Item FT), per ANSI C37.42, are for use in open type fuse cutouts on specifically-sized capacitor banks only. All of these tin element links will carry continuous current up to 1½ times their nominal rating; above 1½ times, or 150% the "Minimum Melt" threshold, melting of the fuse link will start to occur with eventual blowing of the fuse, or weakening of the fuse link causing unpredictable operation in the future. Fuse links rated up to and including 100K or shall only be used in cutouts rated 100 A. Fuse links rated above 100K up to 200K shall only be used in cutouts rated 200 A.

2701.1. Fuse Sizes for Transformers

In general, transformer installations are fused for short circuit rather than overload protection. Three-phase fusing is based on motor loads with incidental lighting, with no motor having a horsepower rating greater than 50% of the total transformer bank capacity in kVA. Special cases, such as exceptionally large motors, may require the next size primary fuse to withstand excessive current drawn during start up. Recommended fuse sizes are shown in TDMIS 2730.

2701.2. Fuse Sizes for Capacitors

In selecting fuse sizes for capacitors, links with adequate continuous overcurrent ratings were chosen to provide a minimum capacity of 135% for Wye connected capacitor banks and 125% for Ungrounded Wye connected capacitor banks to carry excessive currents caused by overvoltage, harmonics, and inrush. Recommended fuse sizes for capacitors are shown in TDMIS 2732.

2701.3. Fuse Sizes for Line Coordination

Where two adjacent fuses operate in series, the "protected fuse" is on the supply side and the "protecting fuse" is on the load side. If a fault develops beyond the protecting fuse, it should clear before the protected fuse has reached 75% of its melting time. This condition can be realized only for most values of short circuit current. Large fuses with high coordinating values are used near the supply end of distribution feeders and must coordinate properly with station protective devices. Transformer fuses always are protecting fuses. Table 2701-1 below shows coordination that can be expected between standard K link fuse sizes.

Table 2701-1

Protecting Fuse Size	Maximum Fault Current for Coordination (A)								
	Protected Fuse Size								
	15	20	25	40	50	65	80	100	140
10	330	580	800	1600	2050	2600	3300	4500	7000
15		460	730	1500	2050	2600	3300	4500	7000
20			560	1350	1900	2500	3300	4500	7000
25				1000	1600	2200	3000	4300	7000
30					1300	2000	2800	4200	7000
40						1700	2600	3800	6600
50							2200	3600	6400
65								3100	6000
80									5500
100									4700

2702. CONTINUOUS RATING

All devices have a continuous rating for current carrying capacity in the closed position. This rating is not to be interpreted as the disconnecting rating.

Devices used for line fuses, disconnects, and primary services shall be selected so that the anticipated load will not exceed the continuous current rating of the device. It is recommended in those areas exhibiting a past pattern of growth that the device be selected so that its initial loading will not exceed two-thirds of the continuous rating, thereby permitting a margin for growth.

2703. DISCONNECT RATING

The ability to disconnect load is dependent upon operating voltage, separation of contacts, power factor, atmospheric conditions, the exact instant of break point in respect to the 60-cycle wave, and other factors beyond the control of the operator.

There is no official recognition that cutouts, fused or solid blade, have the ability to disconnect load (ANSI C37.40). All cutouts and disconnects include loadbuster hooks for the use of the loadbuster tool. When the loadbuster tool is used, loads up to the continuous rating of the device, but not to exceed 600 A, may be interrupted.

Cutouts shall be selected so that they will not be required to open loads in excess of the values shown in Table 2704-1, except cutouts for capacitor applications.

2704. INTERRUPTING RATING

2704.1. Cutout

The maximum fault current that a cutout can successfully perform circuit interruption is known as the interrupting rating of the cutout. It is expressed in root mean square (rms) asymmetric amperes.

Proper application of fused cutouts require selection of an interrupting rating greater than the available fault current at the given location. Interrupting ratings of cutouts are shown in Table 2704-1.

The available fault current, which a fused device is required to interrupt, is dependent upon many factors including:

1. Impedance at the fault.
2. Available fault current at the substation bus.
3. Size, type, and configuration of conductor supplying the fault.
4. Distance from the substation bus.
5. Point on voltage wave at the instant of the fault,
6. Fault duration.

Short circuit analysis is used for determining available fault current values.

Table 2704-1

Cutout and Disconnect Selection and Rating Table				
Item ID	**Description**	**Continuous Current (A)**	**Interrupting Current (A_{RMS})**	
			Sym.	Assym.
CO1	Open type cutout w/ 100 A fuse tube	100	7,500	10,000
CO1L	Open type loadbreak cutout w/ 100 A fuse tube	100	7,500	10,000
CO2	Open type cutout w/ 200 A fuse tube	200	8,600	12,000
CO2L	Open type loadbreak cutout w/ 200 A fuse tube	200	8,600	12,000
D1	Open disconnect switch	600	N/A	N/A

2704.2. Recloser

Reclosers shall be selected so that the calculated symmetrical fault current will not exceed the nameplate interrupting rating of the recloser.

2705. SELECTION GUIDE

Cutouts and disconnecting devices shall be selected as follows:

2705.1. Line and Riser Cutouts

Open-type cutouts with loadbuster hooks shall be used as line and riser fuses where the calculated symmetrical fault current is less than 7,500 A.

At junction pole locations where sectionalizing is necessary, line fuses can be installed on the first pole in or at the junction pole depending upon existing clearances and construction involved.

2705.2. **Overhead Transformer Cutouts**

Cutouts for overhead transformers should be selected in accordance with Table 2731-1 and Table 2731-2. Transformer cutouts can be located at the tap pole for fuse coordination or bucket accessibility purposes provided they feed a single transformer.

2705.3. **Overhead Capacitor Cutouts**

Cutouts for overhead capacitors should be selected in accordance with Table 2732-1.

2705.4. **Line Switches – Single Blade**

Open-type cutouts or disconnect switches depending upon load characteristics with loadbuster hooks shall be used on all circuits. In-line disconnect switches, are recommended where clearances will not allow switch installation on crossarms.

2705.5. **Airbreak Switches – Group Operated**

In order to provide superior customer service, eliminate the effects of ferroresonance, improve upon interruption duration indexes and simplify operating requirements on critical feeder sections, the use of group operated airbreak switch devices is recommended on three phase lines.

Generally, the appropriate use of three phase reclosers at major feeder bifurcation points and beyond critical loads should adequately segment the feeder load into reasonable load groups, 2.5 MVA or less. Group operated airbreak switch devices should be used in the following circumstances:

1. Normally open tie points between feeders fed from two sources.
2. Long three phase underground and/or delta circuits.

3. Critical load (e.g. hospitals, prisons, shopping centers, etc.) that can be fed from two alternative sources with normally open ties.
4. Key tie points that are frequently utilized (two or more times a year).
5. First switch away from substation riser pole.
6. Large floating wye-delta stepdown (ratio) bank installations eliminating ferroresonant conditions during switching routines.

Operating mechanism shall be locked in the open or closed position.

2705.6. **Regulator Bypass Switch**

A non-loadbreak, sequenced, make-before-break switch, designed to by-pass and safely disconnect a regulator from the line once the regulator is in the neutral position.

2705.7. **Reclosers**

Line reclosers enhance safety, improve customer reliability, and offer load side fault protection. Their general function is to sense and interrupt fault current, re-energize the line if the fault is of a temporary nature, and sectionalize non self-clearing faulted sections of distribution circuits. They may also be installed in loop sectionalizing applications or be supervisory controlled to improve distribution system reliability.

The SEL-651R control is specified for use with the G&W Viper-ST recloser head. There is one SEL-651R control that can be applied to: radial installations, sectionalizing and tie reclosers in loop scheme configurations, and automatic source transfer applications. Separate controls are no longer needed for different system applications. Recloser control cabinets shall include proper identification including documentation on the inside door and appropriate labeling on the outside door.

2705.7.1. Radial Recloser Applications

Radial reclosers operate as overcurrent protective devices. Radial applications require a 120 V supply from the source side for control and closing functions. In addition, the control can also accommodate a 120 V supply from the load side for AC transfer capability. The load side supply shall be connected when practical or as required (e.g. back-feeds, reliability). The 120 V supplies shall be connected to the X1 leg to assure correct 3 phase power analog values.

General 15-kV class recloser packages are furnished by the manufacturer as pre-wired, site ready units. These recloser packages include transformation to meet the recloser and control power requirements.

If DOP-owned secondary exists on a structure where a radial recloser is to be installed, the existing secondary may be used to meet the power requirements. If a possibility of backfeed exists, control requires both source and load side single phase secondary supplies. Therefore, the secondary crib must be split at the recloser structure. Both source and load side secondary supplies can be fed from any phase; however, phasing must be noted and accounted for in the control settings. It is not necessary for these 120 V secondary supplies to be in phase due to the break-before-make nature of the AC transfer switch.

2705.7.2. <u>Loop Scheme Recloser Applications</u>

Loop scheme reclosers protect against overcurrent and automatically isolate the faulted section of a feeder, minimizing the outage duration for customers not directly affected. Reconfiguration is done based on loss of voltage detection, and it does not require any type of remote communications to function. These applications automatically isolate a faulted section of a feeder and restore power to the unaffected sections of the feeder, normally within one minute. Since most faults are transient in nature, loop sectionalizing applications must be programmed to only function when the substation breakers or line reclosers trip to lockout indicating a permanent fault has occurred.

The SEL-651R control requires a 120 V supply for the control and closing functions on both sides of the tie recloser and on the source side of the sectionalizing recloser. In addition, the sectionalizing recloser requires 120 V supply on the load side.

Recloser packages are furnished by the manufacturer as pre-wired, site-ready units and include a frame mounted potential transformers to meet the recloser and control power requirements, as well as three phase integrated voltage sensing on the Source 1 (“line”) and Source 2 (”load”) side. As such, these voltage specific recloser packages do not require additional DOP-supplied transformation for loop scheme sectionalizing applications. The potential transformers shall be installed on the line and load side of the recloser to maintain adequate control power.

2706. FAULT CIRCUIT INDICATORS

Automatic reset type Fault Circuit Indicators (FCI) are available and are used in an attempt to reduce operating call out time by helping to pinpoint circuit faults. If a fault occurs, a target on the indicator appears or changes color.

2706.1. Application

FCIs should be used at selected locations such as:

1. Unfused three-phase lines.
2. Unfused single-phase lines.
3. Load side of three-phase switches.
4. Locations not easily accessible by line worker personnel (e.g. rights-of-way, back yard construction, etc.)

2707. INSTALLATION – CUTOUT AND DISCONNECTING DEVICES

Typical installations are shown in Section 2730. Cutouts should be turned toward the pole for easier opening. Disconnect switches should be installed so that normally the blade opens away from the circuit source. In addition, the location of all disconnecting devices shall be chosen to minimize the possibility of an arc flaring up, or being blown into other circuits.

All mainline switching devices shall be properly numbered and located per construction drawing requirements.

Conductors inserted into the terminals of cutouts and disconnects shall be copper or electrically equivalent aluminum.

2708. MEASUREMENT AND PAYMENT

2708.1. Method of Measurement

The method of measurement shall include all switches, hardware, labor, equipment, tools, supervision, and miscellaneous require for a complete and operational assembly.

2708.2. Basis of Payment

Items	Unit	Description
TDMIS-2736	each	Line/riser cutout
TDMIS-2731	each	Overhead transformer cutout
TDMIS-2732	each	Overhead capacitor cutout
TDMIS-2738	each	Line switches – single blade
TDMIS-2741	each	Group-operated air break switch
TDMIS-2747	each	Line regulator bypass switch
TDMIS-2744	each	Line recloser assembly
TDMIS-2746	each	Line recloser assembly with primary riser deadend

2730. CONSTRUCTION DRAWINGS

2731. FUSE SELECTION FOR OVERHEAD AND UNDERGROUND TRANSFORMERS

Table 2731-1: Single Phase Transformer Fusing

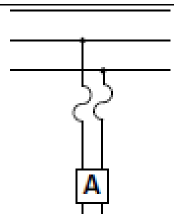
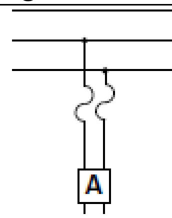
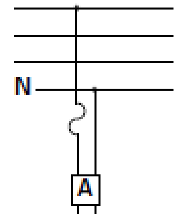
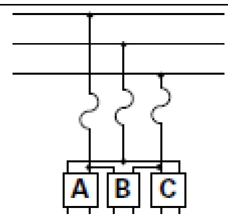
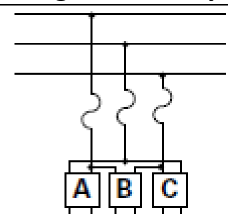
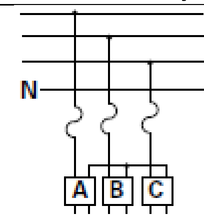
Distribution Transformer Fusing - Single Phase						
Primary Connection	Delta		Ungrounded Wye		Grounded Wye	
	 7,200 V Δ		 14,400 V Ungrd. Y		 14,400 Grd. Y / 8,320 V	
Trans. Size (KVA)	Full Load (A)	Fuse Link	Full Load (A)	Fuse Link	Full Load (A)	Fuse Link
10	1.4	3 K	0.7	3 K	1.2	3 K
15	2.1	6 K	1.0	3 K	1.8	3 K
25	3.5	6 K	1.7	3 K	3.0	6 K
50	6.9	8 K	3.5	6 K	6.0	8 K
75	10.4	12 K	5.2	6 K	9.0	12 K
100	13.9	15 K	6.9	8 K	12.0	15 K
167	23.1	30 K	11.6	12 K	20.0	25 K
250	34.7	40 K	17.4	20 K	30.1	40 K
333	46.3	50 K	23.1	30 K	40.1	50 K
500	69.4		34.7	40 K	60.1	80 K

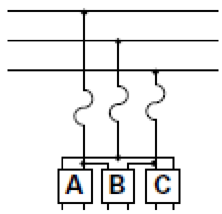
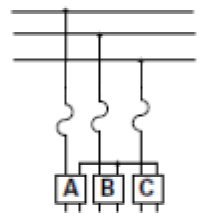
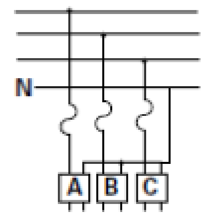
Table 2731-2: Three-Phase Transformer Fusing

Distribution Transformers Fusing - Three Phase						
Primary Connection	**Delta**		**Ungrounded Wye**		**Grounded Wye**	
	 **7,200 V Δ**		 **14,400 V Ungrd. Y**		 **14,400 Grd. Y / 8,320 V**	
Trans. Bank Size (KVA)	Full Load (A)	Fuse Link	Full Load (A)	Fuse Link	Full Load (A)	Fuse Link
75	6.0	8 K	3.0	6 K	3.0	6 K
150	12.0	15 K	6.0	8 K	6.0	8 K
225	18.0	25 K	9.0	12 K	9.0	12 K
300	24.1	30 K	12.0	15 K	12.0	15 K
500	40.1	50 K	20.0	25 K	20.0	25 K
750	60.1	80 K	30.1	40 K	30.1	40 K
1,000	80.2	100 K	40.1	50 K	40.1	50 K
1,500	120.3	140 K *	60.1	80 K	60.1	80 K
2,000	160.4		80.2	100 K	80.2	100 K
2,500	200.5		100.2	140 K *	100.2	140 K *

* Non-standard application. Fuses will not coordinate with breaker. Contact Distribution Engineering.

2732. FUSE SELECTION FOR OVERHEAD CAPACITORS

Table 2732-1: Overhead Capacitor Bank Fusing

Distribution Capacitor Bank Fuse Table							
Primary Connection		Delta[1]		Ungrounded Wye		Grounded Wye	
		 7,200 V Δ		 7200V Δ / 14,400 Ungrd. Y		 14,400 Grd. Y / 8,320 V	
Cap. Bank Size (KVAR)		Full Load (A)[2]	Fuse Link	Full Load (A)[2]	Fuse Link	Full Load (A)[2]	Fuse Link
1Φ	3Φ						
50	150	10.0	10 T	5.0	6 T	5.4	12T
100	300	20.0	20 T	10.0	10 T	10.8	30 K
150	450	30.1	30 K	15.0	15 T	16.2	40 K
200	600	40.1	40 K	20.0	20 T	21.7	50 K
300	900	60.1	65 K	30.1	30 K	32.5	50 K
400	1,200	80.2	80 K	40.1	40 K	43.3	65 K
450	1,350	90.2	100 K	45.1	50 K	48.7	65 K
600	1,800	120.3	Note 3	60.1	65 K	65.0	80 K
800	2,400	160.4	Note 3	80.2	80 K	86.6	100 K
900	2,700	180.4	Note 3	90.2	100 K	97.4	100 K

1) Delta connected capacitor banks are not allowed for new installations. New installations on 7200V Delta distribution shall be connected Ungrounded Wye
2) Full Load (A) is calculated from Cooper Power Series TD230005EN
3) Fusing greater than 100K is not allowed due to Capacitor Tank Rupture Curve

2733. STANDARD FUSE LINKS

K Link	
Size	**TDMIS ID**
3	FK3
6	FK6
8	FK8
10	FK10
12	FK12
15	FK15
20	FK20
25	FK25
30	FK30
40	FK40
50	FK50
65	FK65
80	FK80
100	FK100
140	FK140

T Link	
Size	**TDMIS ID**
6	FT06
10	FT10
12	FT12
15	FT15
20	FT20
25	FT25

Fused Elbows	
Size	**TDMIS ID**
10	FE10
12	FE12
25	FE25
40	FE40
65	FE65
80	FE80