Discussion of New Dual Nameplate kVA for Distribution Transformers

IEEE Transformer Committee

DOE Task Force

Fall 2020

Temperature Rise Limits at Continuous Nameplate kVA with 30C Ambient

Insulating Liquid	Mineral Oil		Ester				
Thermal Class	120	130	120	130	140	155	180
Top Oil Rise	65	65	90	90	90	90	90
Average Winding Rise	65	75	65	75	85	95	115
Hot Spot Rise	80	90	80	90	100	115	140

Peak Temperature when Loaded Beyond Nameplate kVA

Insulating Liquid	Mineral Oil		Ester				
Thermal Class	120	130	120	130	140	155	180
Top Oil Maximum	120	120	140	140	140	140	140
Hot Spot Maximum	180	180	180	180	180	195	220

- Mineral Oil + Thermally upgraded kraft paper is 120 Thermal Class
- Ester + Thermally upgraded kraft paper is 140 Thermal Class
- Maximum peak load 200% of nameplate kVA

Example Overhead Transformers Dual kVA Continuous Loading

kVA 65/85C Rise	10/17		15/22		25/34		50/60		100/118	
Winding Rise C	38	85	47	85	53	85	65	85	65	85
% Impedance	1.99	3.55	2.19	3.30	2.12	2.93	1.95	2.37	2.73	3.25
% Regulation	1.89	3.44	2.02	3.12	1.88	2.66	1.68	2.07	2.15	2.60
Total Watts	160	510	233	490	332	599	564	800	1073	1514

- Example designs use natural ester + thermally upgraded kraft paper 140 thermal class
- Base kVA based on 65C winding rise and meets DOE minimum efficiency
- Thermal kVA based on 85C winding rise
- Reference temperature for losses based on winding rise + 20C
- 10, 15 and 25kVA designs are constrained by minimum mechanical requirements
- Voltage regulation based on 0.85 power factor

Example Overhead Transformers Dual kVA Peak Loading

kVA 65/85C Rise	15/22		25/34		50/60		100/118	
Ambient Profile	SI	W/SC	SI	W/SC	SI	W/SC	SI	W/SC
65C Peak kVA	20	23	30	35	55	65	110	130
85C Peak kVA	26	29	39	44	68	76	130	145
% Impedance	4.08	4.63	3.42	3.93	2.70	3.10	3.58	4.05
% Regulation	3.92	4.46	3.14	3.65	2.40	2.80	2.89	3.33

Utility Peak kVA set as the max load that would not exceed:

- Hot Spot of 190˚C mineral oil or 200˚C natural ester
- Top Oil of 110˚C mineral oil or 120˚C natural ester
- Total Aging of 13,140 hours (1 1/2 years of aging in a single year)

Summer Interior (SI) or Winter/Summer Coastal (W/SC) ambient based on 2006 heat-storm year hourly temperature profile

Load Shape – average customer load shape curves from 2006

Note: In these particular cases, the 120˚C top oil max was the limiting factor

Design and Application Considerations for Dual kVA Transformers

Transformer Design Considerations

- ✓ Material selection to meet desired thermal class
- ✓ Thermal design differences for different liquids
- ✓ Coil ducting practice (size, quantity and location) to support higher loads
- ✓ Component selection for higher continuous loads (leads, bushings, switches, etc)
- ✓ Switching and load interrupting at higher loads and liquid temperatures.
- ✓ Under oil fuse and LV breaker operation. Is de-rating required for higher oil temperatures?
- ✓ Gaskets and seals for different liquids and temperatures
- ✓ Gas space volume, liquid level and tank pressure coordination
- ✓ Maximum conductor temperatures under long duration short circuit

Transformer Application Considerations

- ✓ Conductor sizing for transformer installation
- ✓ External fuse selection
- ✓ Maximum voltage drop at peak loads
- ✓ External transformer touch temperature (eg, padmounts)