GUIDELINES FOR USAGES OF AMORPHOUS CORE OR CRGO CORE DISTRIBUTION TRANSFORMERS

CENTRAL ELECTRICITY AUTHORITY

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1. INTRODUCTION:

Distribution transformers (DTs) constitute one of the the largest group of equipment in the electrical network and therefore losses in the Distribution Transformers constitute the major amount of total losses in the network. The most efficient distribution transformers, which are in service continuously record a loss of approximately 2 to 4% of the electricity they conduct, and electric utilities and industries are constantly searching for methods and technologies to reduce operating costs and energy losses

Distribution transformers carry a load which varies from time to time during the day & night but generally capacity of these Transformers are taken to cater for the maximum load during the day. However, often the average load on DT is far less than the maximum load which occur only for few hours in a day. Keeping in view the average loading of Distribution Transformer, all day efficiency or efficiency at lighter loads have much significance for reducing network losses of any utility.

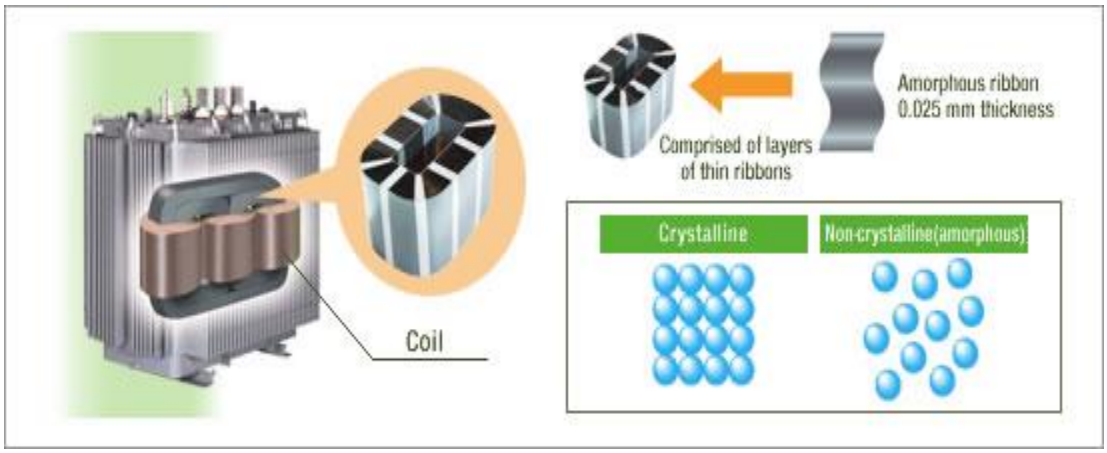
LOSSES IN DISTRIBUTION TRANSFORMERS:

Losses in a distribution transformer consist of no-load losses, which are independent of the load, and load losses which dependent on the loading of transformer. A low load factor means that no-load losses can form a high percentage of the total losses in the transformer, and the design of distribution transformers is focused strongly on reducing these no-load losses without compromising the performance of the transformer.

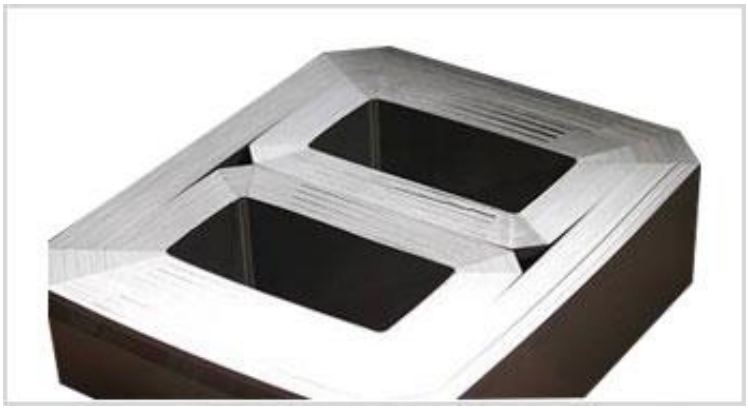
The prime component of losses i.e no-load loss, can be reduced by better design and using core made of superior grades of electrical steels . By using improved grades/ superior grades of CRGO laminations, the no load loss can be reduced significantly. The development of Amorphous Metal Distribution Transformers (AMDT) offers further reduction of core losses of transformers as compare to CRGO core losses.

Amorphous core material (AM) offers both reduced hysteresis loss and eddy current loss because this material has a random grain and magnetic domain structure which results in high permeability giving a narrow hysteresis curve compared to conventional CRGO material. The use of second hand and impure CRGO also contributing for higher loss for DT with CRGO.

Eddy current losses are reduced by the high resistivity of the amorphous material, and the thickness of the film. The laminations comprise of thin ribbons and the thickness of the sheet is about 1/10th that of the CRGO, i.e. approximately 0,025 to 0,030 mm. Amorphous core transformers offer a 70 to 80% reduction in no-load losses compared to transformers using CRGO core material for the same rating of Distribution Transformers.



Amorphous Core



CRGO Core

The typical comparative figures of No load losses of AMDT and CRGO core are given below.

Transformer size (kVA)	**AMDT**	**CRGO DT**	**% Loss reduction**
100	65	145	55%
250	110	300	63%
400	170	430	60%

Material	Saturation flux density (T)	Electrical resistance (μΩ- cm)	Iron loss (W/kg)	Thickness (mm)
Silicon steel (Crystalline)	2.03	50	0.440	0.23
Amorphous Alloy (Non-crystal line)	1.56	130	0.070	0.025

COMPARISON OF CRGO AND AMORPHOUS CORE DTs:

- AM cores have a lower saturation point : amorphous metal cores saturate at a lower flux density than CRGO, which requires larger coils for the same capacity.

- Due to small thickness and low saturation factor, larger core and consequently larger coils and tank size are required as compared to CRGO core transformers.

- The other significant difference between amorphous core transformers and CRGO transformers is the cross-sectional structure of the core. Because of the difficulty of producing amorphous strips, there are limited production sizes available (typically 213 mm, 170 mm, and 140 mm). Although

conventional CRGO transformers can be oval or round in cross-section, amorphous cores may be square or rectangular in shape.

- The cost of the same capacity of amorphous core transformer is generally also more than CRGO core transformers.

- The AM Core material cannot be re-used in case burning of the core while CRGO core can be reused by repairing some of the stamping of the Core.

- From the repair and service point of view, Discoms and Power Departments raised apprehension about the repair services of the failed transformers with amorphous core and opined that these transformers are difficult to repair and cost of repair is higher, hence increase in the Opex cost of the Discoms and Power Departments. However, recently manufactures of AMDT have clarified the apprehension of Discoms and Power Departments, and manufacturer of AMDT have conducted many workshops at various discoms.

- There are observations of utilities that overload handling capacity of the Amorphous core transformers is less and overloading causes rise in the failure of amorphous core transformers than CRGO core. To protect the transformers with amorphous core there is practice of using the overload protective device in each transformer.

COMPARISON CHART: The comparison chart of the identical rating transformer with CRGO and amorphous core are as below,

Sr. No.	**Comparison point**	**CRGO**	**Amorphous core**
1	**Initial cost**	Comparatively Low	Comparatively High
2	**Maximum losses for particular**	As per IS	As per IS

	rating		
3	**No load losses**	Higher	Lower
4	**Maximum efficiency loading point**	At around 35-40%of rated load	Max. Efficiency point shifts towards more lighter loads
5	**Efficiency at full load**	More efficient as load losses are less	Less efficient as load losses are more
6	**Size of transformer**	comparable	Slightly higher in width
7	**Weight of transformer**	Heavy	Lighter in weight
8	**Repair**	Easy/utilities used to	utilities not used to
9	**Repair agency**	Easily available	limited
10	**Repair cost**	Comparable	High
11	**Overloading capacity**	Can take short interval overloads	Overloading is very detrimental for life of transformers

Requirements of Distribution Transformer as per Indian Standard (IS 1180)

Since long most of Discoms and Power Departments are procuring DTs with CRGO core, but after the notification of IS 1180 :2014 & the Gazette Notification issued by Ministry of Power from 2014 to 2016, it has become mandatory to procure Transformers which meet the norms of Losses. As per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Amendment Regulation 2015, Distribution Transformer should be as per relevant Indian Standards.

As per the quality control order all the distribution transformers have to comply to the IS 1180 part 1 guidelines and the total losses shall be within the limits of specified in IS 1180 and complying to BE star labeling. The recommended maximum losses as per IS 1180 are as below:

Sl No.	Rating (kVA)	Impedance (Percent)	Maximum Total Loss (W)					
			Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
			50 % Load	100 % Load	50 % Load	100 % Load	50 % Load	100 % Load
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	250	4.50	1 050	3 150	980	2 930	920	2 700
ii)	315	4.50	1 100	3 275	1025	3 100	955	2 750
iii)	400	4.50	1 300	3 875	1 225	3 450	1 150	3 330
iv)	500	4.50	1 600	4 750	1 510	4 300	1 430	4 100
v)	630	4.50	2 000	5 855	1 860	5 300	1 745	4 850
vi)	800	5.00	2 459	7 300	2 287	6 402	2 147	5 837
vii)	1 000	5.00	3 000	9 000	2 790	7 700	2 620	7 000
viii)	1 250	5.00	3 600	10 750	3 300	9 200	3 220	8 400
ix)	1 600	6.25	4 500	13 500	4 200	11 800	3 970	11 300
x)	2 000	6.25	5 400	17 000	5 050	15 000	4 790	14 100
xi)	2 500	6.25	6 500	20 000	6 150	18 500	5 900	17 500

The Bureau of Energy Efficiency has upgraded the star ratings of DTs in December 2016 (applicable from 1st July 2017) and assigned maximum permissible losses based on loading for each rating are as below:

Standard Losses in watts up to 11 KV Class										
Rating (kVA)	Star 1		Star 2		Star 3		Star 4		Star 5	
	50 Per cent. Load	100 Per cent. Load	50 Per cent. Load	100 Per cent. Load	50 Per cent. Load	100 Per cent. Load	50 Per cent. Load	100 Per cent. Load	50 Per cent. Load	100 Per cent. Load
16	135	440	120	400	108	364	97	331	87	301
25	190	635	175	595	158	541	142	493	128	448
63	340	1140	300	1050	270	956	243	870	219	791
100	475	1650	435	1500	392	1365	352	1242	317	1130
160	670	1950	570	1700	513	1547	462	1408	416	1281
200	780	2300	670	2100	603	1911	543	1739	488	1582

Standard losses in watts up to 11 KV Class (For ratings above 200 kVA)											
Rating (kVA)	Per Cent. Impedance	Star 1		Star 2		Star 3		Star 4		Star 5	
		50 Per Cent. Load	100 Per Cent. Load	50 Per Cent. Load	100 Per Cent. Load	50 Per Cent. Load	100 Per Cent. Load	50 Per Cent. Load	100 Per Cent. Load	50 Per Cent. Load	100 Per Cent. Load
250	4.5	980	2930	920	2700	864	2488	811	2293	761	2113
315	4.5	1025	3100	955	2750	890	2440	829	2164	772	1920
400	4.5	1225	3450	1150	3330	1080	3214	1013	3102	951	2994
500	4.5	1510	4300	1430	4100	1354	3909	1282	3727	1215	3554
630	4.5	1860	5300	1745	4850	1637	4438	1536	4061	1441	3717
1000	5	2790	7700	2620	7000	2460	6364	2310	5785	2170	5259
1250	5	3300	9200	3220	8400	3142	7670	3066	7003	2991	6394
1600	6.25	4200	11800	3970	11300	3753	10821	3547	10363	3353	9924
2000	6.25	5050	15000	4790	14100	4543	13254	4309	12459	4088	11711
2500	6.25	6150	18500	5900	17500	5660	16554	5430	15659	5209	14813”;

It may be seen that level–II of IS 1180 :2014 has been made as new Star 1 and level–III of IS 1180 :2014 has been made as new Star 2 by BEE and have introduced new losses for star 3 , 4 & 5. To alien with the BEE notified losses, BIS is in process of amending IS 1180 and the same would be applicable as and when notified by BIS.

All the Distribution Transformers either having CRGO core or Amorphous core have to comply with the total losses (No load losses + load losses) at 50% and 100% loading given in the IS 1180 and BEE notifications. The load losses of the distribution transformers also play a major role in calculation of total losses at 50% and 100% loading as the winding of DT may be designed by using proper size of Aluminum or Copper winding to meet the total losses criteria keeping in view the no load losses of available core of CRGO or Amorphous.

As per the information furnished by some Discoms, during year 2016-17 the cost of purchase for energy efficient DTRs (for compliance of norms of BIS for Level – II and III as per IS 1180:2014 part –I), the cost of 100KVA DTR with CRGO was costlier then amorphous core DTRs. As equal opportunity was given to both type of core material (i.e Amorphous & CRGO) in procurement, utilities have to procure DTRs with Amorphous core .

Also during year 2017-18 in a tender for BIS Level – II for 25 kVA & BIS Level -III for 200 & 315 kVA DTRs floated by the MPPKVVCL Jabalpur, it was observed that lowest rate of 25 kVA DTRs was with CRGO core material & lowest rate of 200 & 315 kVA DTRs was with amorphous material. This shows that rate of CRGO core material is lowest in lower level class and rate of amorphous core material is lowest in higher level.

SUGGESTIONS :

- Discoms should give equal opportunity to both type of DTs-AMDTs & CRGO DTs by specifying the energy efficiency level as notified in IS :1180 and as notified by Ministry of Power while procuring the DTs. It should be left open to the manufacturers to offer the type of DTs–AMDT or CRGO DTs, that he considers more suitable to meet the energy efficiency norms or losses as specified in the specification of Discoms at lowest cost.
- If Discoms are following Total Owning Cost(TOC) principle for evaluation of tenders, them they may evaluate the successful bidder on the lowest Total Owning Cost formula as specified in Bid documents, based on the Cost of DT and Losses guaranteed in the bid. The formula for TOC has been given in the SBD of DDUGJY and IPDS.
- As no load losses of AMDTs are less than CRGO core DTs, these DTs may be preferred in villages where peak load comes for a short period and most of the time DT remains lightly loaded.
- The impact of harmonics has not been considered in calculation of load losses. AMDTs are known for positive response for reduction of Load loss under harmonics conditions. This is an additional advantage for of AMDTs in today’s environment of increasing nonlinear loads in the Distribution system.