

<b>SUBSTATION MAINTENANCE INSTRUCTION</b>	<b>TITLE</b>  REHABILITATION OF FREE-BREATHING HIGH VOLTAGE BUSHINGS	<b>Page</b>  No. 6476 000 4
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TRANSMITTAL LETTER NO. S-(I)-64-6

Subject: Rehabilitation of free-breathing high voltage bushings

The attached Substation Maintenance Instruction No. 6476-000-4 presents the guides for power factor evaluation of breather-type bushings. The guides were developed as the result of field tests and laboratory investigation made when several of this type of bushing were found to be in a deteriorated condition. It was established that these bushings are not in a critical condition.

As a further step in establishing the future bushing rebuild program, power factor tests should be conducted on all free-breather bushings. This is not a "crash" program, but every effort should be made to perform the tests at the first opportunity. Power factor data is needed to establish the timing of future budget requirements for the bushing rebuild program.

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Chief of Maintenance

Enclosure

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I. PURPOSE:

To outline a program for test and rehabilitation of breather-type bushings.

II. GENERAL:

All General Electric or Locke Types OF and OFI bushings and Ohio Brass Type G, manufactured prior to 1943, are free breathers. These units are more susceptible to internal deterioration and contamination than sealed types and, therefore, require internal cleaning or rebuilding after 15 to 20 years of service.

Each Area should refer to their inventory records for determination of the number and location of this design of bushing as the system-wide totals of these types will exceed 1000 units. The lists shown on pages 5, 6, 7, 8, and 9 of this Instruction cover most of the bushings in this category but should not be considered to be all inclusive.

Field testing and cleaning should be accomplished as soon as it is economically practical with the highest priority placed on transformers. We would like to have the initial tests completed on transformer bushings by the end of FY 1965.

III. PROCEDURE:

GE or Locke OF and OFI Bushings:

Perform power factor tests on each bushing. (If bushing has capacitance tap, perform UST and tap tests also.)

1. Bushings with a measured power factor between 0.2 and 1.5% corrected to 20° C, are considered to be in serviceable condition. These units should be cleaned in place as shown in the Instruction, page 2.

Circuit Breakers. The expansion chamber sump should be drained at each subsequent mechanism service. Additional power factor tests are to be made at 2 - 4 year intervals or during each complete service and the bowl recleaned.

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Transformers. Subsequent testing and cleaning should be performed when the bank is out of service for other purposes. The preferable schedule for additional attention to these bushings is one year for draining the sump, and two to five years for power factor testing and recleaning of expansion chambers.

2. Units with a measured power factor between 1.5 to 3.5% and those with less than 0.2% when tested by UST methods, corrected to 20°C, require special attention in addition to the cleaning as outlined below. An oil sample shall be obtained, preferably bottom oil, and tested in the field for dielectric, acidity, IFT, and color. Oil test data should be submitted with the power factor test data sheet. Power factor tests shall be performed at one year intervals until the rate of deterioration has been established.
3. Bushings which measure in excess of 3.5% power factor, corrected to 20°C, shall be replaced as soon as possible and the defective unit sent to the Ross Shop for complete rehabilitation.

Field Cleaning of General Electric or Locke Type OF and OFI Bushings.

1. Remove top cap and clean the bowl and sump with a cloth dampened with alcohol. The bowl should be removed from the top casting for cleaning unless it is stuck too tightly. A spare bowl should be readily available as they are fragile and occasionally broken during disassembly.
2. Replace all cork gaskets with nitrile.
3. Replace core seal gasket.
4. Fill the capacitance tap with GE No. 219 compound, or equal. (See page 3 for sketch of bushing.)

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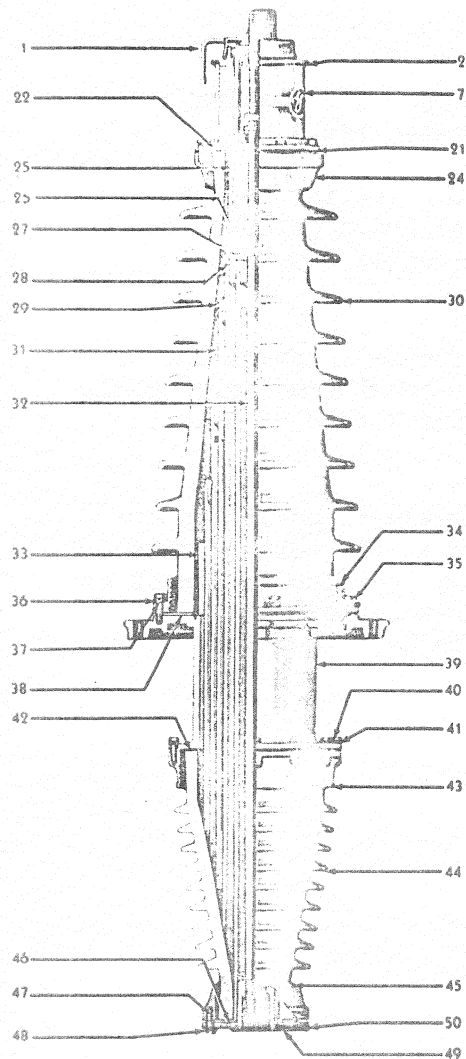


Fig. 32. Sectional view, showing construction which is typical of all Type OF bushings

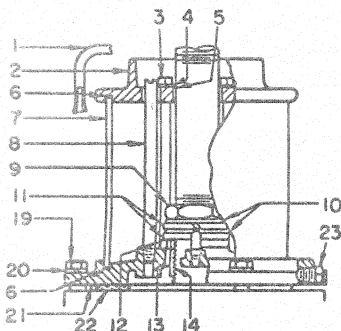


Fig. 33. Details of top of bushing

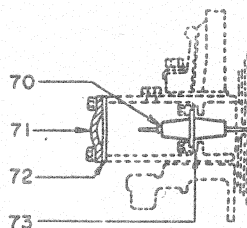


Fig. 34. Details of bushing with capacitance tap

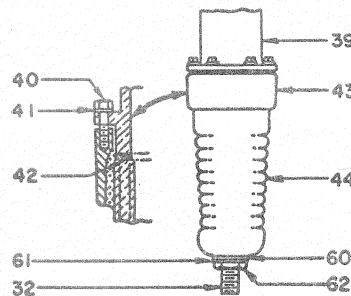


Fig. 35. Details of bottom of 69-kv transformer bushing

Nomenclature For Fig. 32, 33, 34, 35, 37, and 38

PART	NAME OF PART
1	Breather pipe
2	Gage-glass washer
3	Gage-glass bolt
4	Spring washer
5	Plain washer
6	Gage-glass gaskets
7	Gage glass
8	Plug
9	Lock nut
10	Plain washer
11	Spring washer
12	Collar
13	Sleeve gasket
14	Threaded sleeve
19	Top-washer bolt
20	Heavy spring washer
21	Top washer (assembly includes U-tube and drain valve)
22	Top-washer gasket
23	Top-washer drain plug
24	Top clamping ring
25	Terminal shield
26	Clamping nut
27	Spacer
28	Fiber washer
29	Spacing block
30	Top porcelain
31	Herkolite cylinder
32	Central conductor
33	Ground shield
34	Upper intermediate clamping ring
35	Bolt
36	Heavy spring washer
37	Star washer
38	Gasket
39	Support
40	Bolt
41	Heavy spring washer
42	Gasket
43	Lower intermediate clamping ring
44	Bottom porcelain
45	Bottom clamping ring
46	Gasket
47	Bolt
48	Heavy spring washer
49	Bottom washer
50	Bottom-washer drain plug
60	Gasket
61	Washer
62	Flange nut
70	Tap insulator
71	Cover
72	Gasket
73	Gasket
74	Terminal cap
75	Gasket
76	Cable-terminal stud
77	Pin
78	Core-seal gasket
79	Set screw
80	Intermediate cap
81	Cover
82	Pipe plug
83	Cover gasket

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### Ohio Brass Bushings

Perform power factor test on each bushing. (If bushing has capacitance tap, perform UST and tap tests also.)

1. Bushings with a measured power factor within 2% of the value specified on the nameplate are considered to be in serviceable condition. These units should be re-tested in 4 to 5 years.
2. Bushings which show a 2% to 6% increase in power factor over the nameplate values are still considered serviceable but should be retested annually until a rate of deterioration has been definitely established.
3. Bushings which measure over 6% increase in power factor should be scheduled for replacement at the next service (maximum of 3 years). Units with an increase in excess of 10% should be replaced at the earliest opportunity. Defective units shall be sent to the Ross Shop for rehabilitation.

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GENERAL ELECTRIC & LOCKE TYPES OF & OFI BUSHINGS

<u>Voltage</u>	<u>Cat. or Dwg. No.</u>	<u>Equipment No.</u>	<u>Each</u>	<u>Location</u>
230 kv	6B642/6B462 86462	T-547, 51-52	3	Redmond
		T-548-49	2	Covington
		T-580-85	6	Longview
		T-608-10	3	Ross
		T-769-72	4	Troutdale
	6B262	T-640-42	3	Hanna
		T-649-51	3	Bell
		T-676-78	3	Troutdale
		T-679-82	4	Longview
		T-725-28	4	Midway
115 kv	6B342/86342	T-503	3	Duckabush
		T-504-10	14	Alcoa
		T-576	2	Storage (Bell)
		T-602-4	3	Chehalis
		T-637-9	3	Foster Creek
		T-690-92	3	Wren
		T-723	3	Coulee City
		T-724	3	Gilmer
		T-736-9	4	Scooteney
		T-741	3	PeEll
		T-742	3	Pomeroy
		T-743	3	Monmouth
		T-745	3	Green Peter
		T-747	3	Nilles Corner
		T-749	3	Wren
		T-750	3	Clarkston
		T-752-5	8	Royal
		T-756	3	Moses Lake
		T-758	3	Jericho
		T-759	3	Oakridge
		T-760	3	Drain
		T-762	3	Lookingglass
		T-763	3	Kalispell
		T-764	3	Creston
		T-777	3	Prairie

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<u>Voltage</u>	<u>Cat. or Dwg. No.</u>	<u>Equipment No.</u>	<u>Each</u>	<u>Location</u>
115 kv	86592	T-805-7	6	Beaver
69 kv	7B157	T-531	3	Goldendale
115 kv	7B165	T-502	3	Yaak
		T-520-2	6	Astoria
		T-525-7	6	Bremerton
		T-557-60	4	No. McNary
		T-561-3	3	Albany
		T-617, 22-3	6	Walla Walla
		T-618, 20-1	6	McMinnville
		T-619	2	Spare (Ross)
		T-661	3	Black Rock
		T-684-6	6	Camas
		T-687-9	6	Eastmont
		T-701	2	Spare (Ross)
		T-740	4	Walton
		T-751	1	Spare (Ross)
	7B166/87166	T-547, 51-52	6	Redmond
		T-548-49	4	Covington
		T-580-5	12	Longview
		T-608-10	3	Ross
		T-640-2	3	Hanna
		T-769-72	8	Troutdale
69 kv	86071	T-602-4	6	Chehalis
		T-690-2	6	Wren
		T-721	3	Storage
		T-765	3	Morton
	6B72/86072	T-637-39	3	Foster Creek
		T-543-46	8	Cosmopolis
	6B73	T-676-78	3	Troutdale
		T-679-82	4	Longview
	6B81	T-557-60	4	No. McNary
	7B157/87157	T-632	3	Storage
		T-693	3	Sweet Home
		T-605-07	6	Scooteney
	7B169	T-617, 22-23	6	Walla Walla
		T-618-20, 21	6	McMinnville
		T-619	2	Spare (Ross)
	7B187/87187	T-547, 51-52	3	Redmond
		T-548-49	2	Covington
		T-580-85	6	Longview
		T-649-51	3	Bell
		T-769-72	4	Troutdale



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Voltage	Cat. or Dwg. No.	Equipment No.	Each	Location	
230 kv	6B473	0-490	6	Longview	
		0-491	6	Roundup	
		0-494	6	Snohomish	
	86473	0-489	6	Scheduled Redmond	
		0-25	6	Bellingham	
	86478	0-286	6	Detroit	
		0-340	6	Bell	
	87699	0-375	6	Troutdale	
		0-118-119	12	No. Bonneville	
	7B206	0-120	6	Longview (all to be retired)	
		0-213	6	Covington	
	7B250	0-522	6	Chehalis	
		0-523-4-5	18	Covington	
	7B676	0-526	6	Maple Valley	
		0-521	6	Covington	
115 kv	6B348	0-95	6	Tillamook	
		0-150	6	Holcomb	
		0-151-2-3-4	24	Chehalis	
		0-173	6	Lebanon	
		0-220	6	Bandon	
		0-300	6	Aberdeen	
		0-308	6	Walla Walla	
		0-333	6	Cottage Grove	
		0-334	6	Bonners Ferry	
		0-335	6	Richland	
		0-336	6	Raymond	
		0-339	6	Reedsport	
		0-3	6	Richland	
		0-5	6	Shelton	
	86348	0-6	6	Okanogan	
		0-7-8-9	18	Ross	
		0-10	6	Salem	
		0-11	6	Ross	
		0-12	6	Tillamook	
		0-14	6	Shelton	
		0-72, 76-77-78	24	Alcoa	
		0-180	6	Longview	
		0-299	6	Silver Bow	
		0-301	6	Loan to PP&L	
		0-305	6	Grandview	
	86353	0-464	6	Albany	
		0-465-66	12	Lookout Point	
		0-467	6	Hells Creek	
		0-479	6	Toledo	
		0-480	6	Longview	
		0-485	6	Troutdale	



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115 kv	87151	0-15	6	Fairmount	
		0-169	6	Astoria	
		0-170	6	Fairview	
		0-207-8	12	Cosmopolis	
		0-217	6	Kitsap	
		0-257	6	Toledo	
		0-258-9	12	Fairview	
		0-260	6	Fairmount	
		0-261-2	12	Kalispell	
		0-315	6	Colfax	
		0-322	6	Keokuk	
		87154	0-263	6	Tillamook
			0-264-5	12	Salem
			0-266	6	Astoria
		69 kv	86088 7B158	0-376	6
0-155-6	12			Fossil	
0-157	6			Potlatch	
0-158	6			Scooteney	
0-196	6			Redmond	
0-197	6			Goldendale	
0-198	6			DeMoss	
0-268	6			Redmond	
0-269	6			DeMoss	
0-270	6			Pilot Rock	
0-271	6			Redmond	
87163	0-309			6	Silver Creek
	0-455			6	Wren
	0-457			6	Aberdeen
	0-458			6	Port Angeles
	0-459			6	Salem
T-299022603	0-460			6	Port Angeles
	0-461			6	Chehalis
	0-199			6	Silver Creek
	0-200			6	Odessa

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OHIO BRASS BUSHINGS WHICH MAY BE AIR BREATHERS

<u>Voltage</u>	<u>Cat. or Dwg. No.</u>	<u>Equipment No.</u>	<u>Each</u>	<u>Location</u>		
230 kv	39594	0-130	6	Bellingham		
		0-1092-3	12	Troutdale		
115 kv	36789	0-47	6	Gold Beach		
		0-298	6	Richland Sw.		
		0-307	6	Walla Walla		
		0-317	6	Brewster		
		39581	0-231	6	Tacoma	
			0-232-33	12	Tahkenitch	
			0-234	6	Tacoma	
			0-302	6	Grandview	
69 kv	34718	0-96-97	12	Santiam		
		0-98	6	McMinnville		
		0-99	6	Lebanon		
		0-100	6	Salem		
		0-101-02	12	Redmond		
		0-103	6	Salem		
		0-104	6	McNary		
		0-105	6	Redmond		
		15 kv	34774	0-18-19	12	Ross
115 kv	34601 36282 37329	T-628-30	6	Salem		
		T-536-38	3	Goldendale		
		T-539	3	Lease to WWP		
		T-665	3	Elmo		
69 kv	32487 34818 36281 37012 39523 39782	T-662-64	6	Stock		
		T-628-30	6	Salem		
		T-536-38	6	Goldendale		
		T-694-96	6	Pendleton		
		T-523	3	Mossy Rock		
		T-577-79	6	Jerita		
		T-596-98	6	White Swan		
15 kv	36256 37040	T-536-38	3	Goldendale		
		T-628-30	6	Salem		