



Iron-Core Filter Reactors

NEPSI's Metal-Enclosed Harmonic Filter Banks typically come equipped with single-phase or three-phase Iron-Core harmonic filter reactors. They are tuned as required for the application. In most applications, the reactors tune the capacitor bank to a frequency near the 5th harmonic (i.e. 270 hertz). In systems with complex system impedance profiles, or systems with large harmonic producing devices, the reactors may tune the capacitor bank to a number of different frequencies between the 2nd and the 25th harmonic.



Figure 1: Typical Iron-Core Reactor Installation

Iron-Core Reactor Specifications

Reactor Type	Three (3) Single-Phase or one (1) Dry-Type, Iron-Core, Indoor, Series Connected. See Figure 2 for typical reactor design showing use of a single-phase reactor. Single-phase reactors are typically mounted on insulators with mid -point of the winding tacked to the core with an insulated shield wire.
Winding	Copper or Aluminum Magnet Wire, or Foil, as required to reduce eddy current heating and minimize cost.
Inductance	Inductance and 50/60Hertz Reactance as required based on filter tuning point and capacitor bank rating. A) Tolerance of $\pm 5\%$ (typical) or $\pm 3\%$ when required.
Reactor Insulation System	220C—Nomex Insulation
Winding Temperature Rise	130C temperature rise on a 60C ambient temperature (60C is maximum average temperature in reactor compartment)
Impregnation Process	VPI (Vacuum Pressure Impregnation)
Lamination	High-Grade Magnetic Steel
Standards	There are no specific standards that cover iron-core harmonic filter reactors. NEPSI utilizes the following standards as a guideline in the design, testing, and application of our filter reactors. <ul style="list-style-type: none"> • Tested and built to ANSI/IEEE C57.12.01—General Requirements for Dry-Type Distribution and Power Transformers • C57.16 ANSI/IEEE—Standard Requirements, Terminology, and Test Code for Dry Type Air-Core Series Connected Reactors
Taps	Provided as required
Current Rating	See Design Criteria on Following Page
Arrangement	Reactors are typically placed above the capacitors in the capacitor compartment and are electrically on the line-side of the capacitors. This arrangement is advantageous as reactors tend to have a higher operating temperature than other components.
BIL/Voltage Rating	As required per ANSI C57.12.01.



Design Criteria

The reactor current ratings are typically based on the following considerations:

- The reactor core will not saturate for currents less than 250% of the fundamental current rating of the reactor.
- Peak flux density of the core shall be less than 1.2 - 1.4 Tesla assuming all harmonic current peaks are 100% coincident (Core design is not based on RMS current rating of reactor)
- When specific harmonic current data and system impedance data are provided, the reactor current spectrum is based upon computer simulations and a conservative engineering margin.

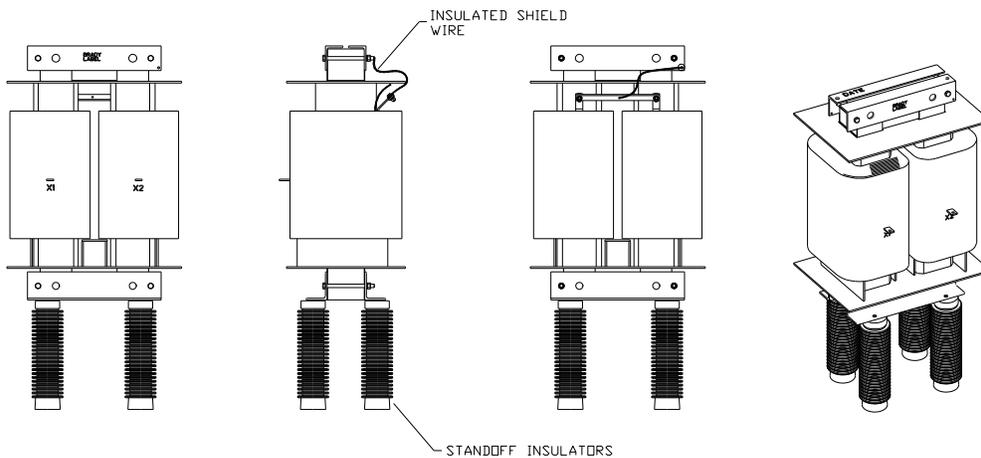


Figure 2: Typical Filter Reactor, Front, Side, Back, and Isometric Views

Routine Test

The following tests are conducted as standard on NEPSI Filter Reactors

- 60Hz Applied voltage test according to Table 3 of ANSI C57.16. Applied winding-to-core voltage shall be as required by standards for the system voltage. Test is conducted with the core shield wire disconnected and pulled back away from the core. Test duration: 1 minute.
- Partial Discharge testing at 110% applied voltage
- Winding resistance testing with 4-wire Kelvin Resistance meter
- Inductance testing: Apply current to reactor and calculate the inductance based on 60 Hertz Current and Voltage measured across its terminals. Resistance from above measurement to be accounted for in this calculation.



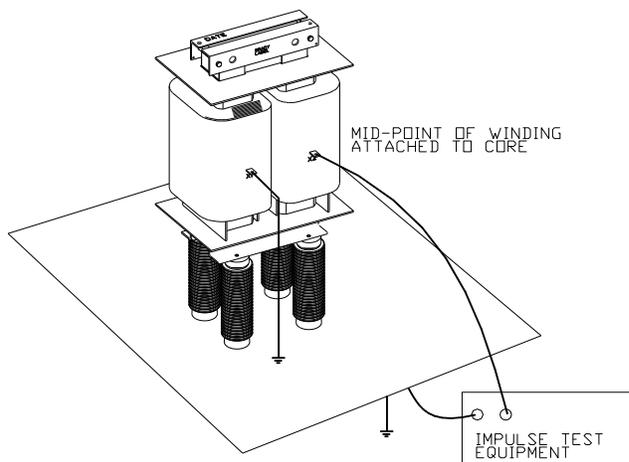
Design Test

As standard, NEPSI does not provide BIL, Heat Run, or Loss Measurement tests. These tests have been conducted by NEPSI in the development of our insulation system and construction practices. When required, at the customer’s option, the following tests can be conducted on a specific iron-core reactor.

- BIL Test per procedures referenced in ANSI C57.16-1996 section 11.3.6. Test will be conducted with leads connected in both directions similar to what is shown in figure 4 below. Test order per KEMA labs is:
 - One Reduced full wave
 - One full wave
 - One reduced chopped wave
 - Two chopped waves
 - Two full waves

- Heat run test according to ANSI C57.16. The test will utilize 60 Hertz current and as such will utilize an “equivalent 60HZ heating value of current” that is higher than the RSS value specified for the reactors to account for the additional heating effect of harmonic current. The “equivalent heating value of current” will be determined based on the design program of the reactor supplier such that the 60HZ losses equal the calculated design losses when operated per the harmonic spectrum specified for the reactor. Hot spot winding temperature will be determined based on the resistance method or temperature probe method.

- Loss measurements will be conducted during heat run test by phase angle measurements or a digital watt meter.



TEST SUMMARY

A. Discussion
 The client submitted one harmonic reactor, in good condition, to be subjected to withstand of dielectric tests in accordance with ANSI C57.16 – 2000. The test sample is rated at 34.5kV, 50A, I_{core} 75MVA, 125kV BIL, 1φ at 60Hz.

B. Test Requirements
 The client requested tests to verify the harmonic reactor’s ability to withstand dielectric in accordance with ANSI C57.16 – 2000. These test requirements are summarized in following table:

Impulse Test Full Wave	
Voltage (kV)	Waveform (ns)
125	1.2 x 50

C. Test Results
 The dielectric withstand test for the harmonic reactor was performed in accordance with the test standards mentioned above and the client’s instructions.
 Detailed results are reported in the Impulse Test Record on page(s) 5-6 of this report.
 This report will be forwarded to the client for evaluation.

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Figure 3: The Certificate to the right shows passing of a 125kV BIL Test conducted by KEMA. The Figure to the left shows how the impulse test is conducted.