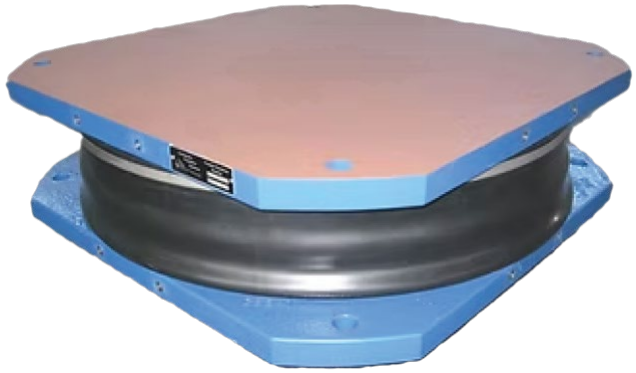
Seismic Base Isolators, Triple Friction Pendulum



1. Scope

This standard covers the requirements for friction-type, seismic base isolators.

2. Application

In the Seattle City Light (SCL) system, seismic isolators are used with high-voltage power transformers in substations.

Seismic base isolators are generally used to protect structures such as buildings, bridges, railways, and offshore oil and gas platforms during seismic events. They are also used in the electric utility industry to protect major substation equipment such as high voltage power transformers.

Seismic isolators that are installed at the base of an equipment or structure are known as base isolators. Each transformer requires four base isolators, one at each corner.

Each set of four isolators shall be supplied with 64 shear-lug bolt assemblies.

3. Industry Standards

Isolators shall meet the applicable requirements of the latest revision of the following industry standards:

ASCE 7; Minimum Design Loads for Buildings and Other Structures

IEEE 693; IEEE Recommended Practice for Seismic Design of Substations

I**SO 9001:2015 Certification 1022751**, Design and Manufacture of Seismic Isolators.

4. Requirements

4.1 General

Isolators shall be designed to meet the following requirements:

Requirement	Value
Weight capacity per isolator	60 kips, minimum, 1142 kips, maximum
Friction, maximum	20%
Displacement	
Design EQ (in)	16
Max EQ (in)	26
Capacity	≥2.0 x DM[1]
Shear strength	≥2.0 x shear strength at DM[1]
Seismic demand	Risk Category IV per ASCE 7
Soil type	Type D or better per ASCE 7
Construction	
Unit weight (lb)	4060
Height (in)	13.5
Length (in)	47.0
Material	Stainless steel
Finish	Weather resistant paint
Nameplate (or label) information	▪ Manufacturer name and catalog number ▪ Test date and test bearing number
Detailed dimensions	See Appendix A
Force displacement loop	See Appendix B

[1] DM = maximum displacement

4.2 Lug Bolts

Eash set of four (4) isolators shall be supplied with 64, 1-1/2-inch-diameter shear lug bolt assemblies.

5. Testing and Reports

Dynamic Property Tests and Quality Control Tests shall be conducted in accordance with the Seismic Isolation Standard for Continued Functionality.

An isolator engineering report shall be provided that includes the design drawings, specifications, calculations, isolator capacities and properties, and Dynamic Property Test and Quality Control Test protocols. The report shall be signed and stamped by a by a Professional Engineer (PE) licensed in the state of California.

In addition, test reports for both the Dynamic Property and Quality Control tests shall be provided that include results for the as-manufactured isolator properties. Reports shall be signed and stamped by a Professional Engineer (PE) licensed in the state of California.

6. Installation Consultation

The manufacturer shall provide installation consultation services for each site where the isolators are installed.

The manufacturer shall visit the site and observe general conditions and confirm that the installation complies with their recommendations.

7. Ordering

An SCL Structural Engineer and the Lead Electrical Engineer shall coordinate the order for the isolators. The Civil Crew Chief shall assist the Structural Engineer with the delivery requirements for the isolators.

8. Shipping and Handling

Isolators shall be shipped to the job site.

Each isolator shall be individually packaged in pallets, as appropriate for their size and weight, to prevent damage during shipping, handling, and storage.

Isolators are not to be stacked at any time.

Isolators shall be shipped in a flatbed truck and be strapped and tarped.

Shear lugs for the isolators shall be packaged and delivered on a separate pallet.

Each package (isolator and shear lugs) shall be legibly marked with the following information:

- Manufacturer identification
- Product description
- Quantity

9. Pallets

9.1 Pallet Material

Pallet and all pallet accessories shall be constructed of unpainted wood that is suitable for outdoor storage through all weather conditions.

9.2 Pallet Support

Pallet shall be 4 inches high to accommodate lifting by both forklifts and pallet jacks.

The most central pallet stringer shall be centered and a maximum of 7 inches wide to ensure picking by pallet jacks.

10. Approved Manufacturers

Manufacturer	Catalog No.
Earthquake Protection Systems	FPT8844/12-10R/9-7

11. References

Seismic Isolation Standard for Continued Functionality, Victor Zayas and Stephen Mahin; University of California, Berkeley; Department of Civil and Environmental Engineering; May 30, 2022

12. Sources

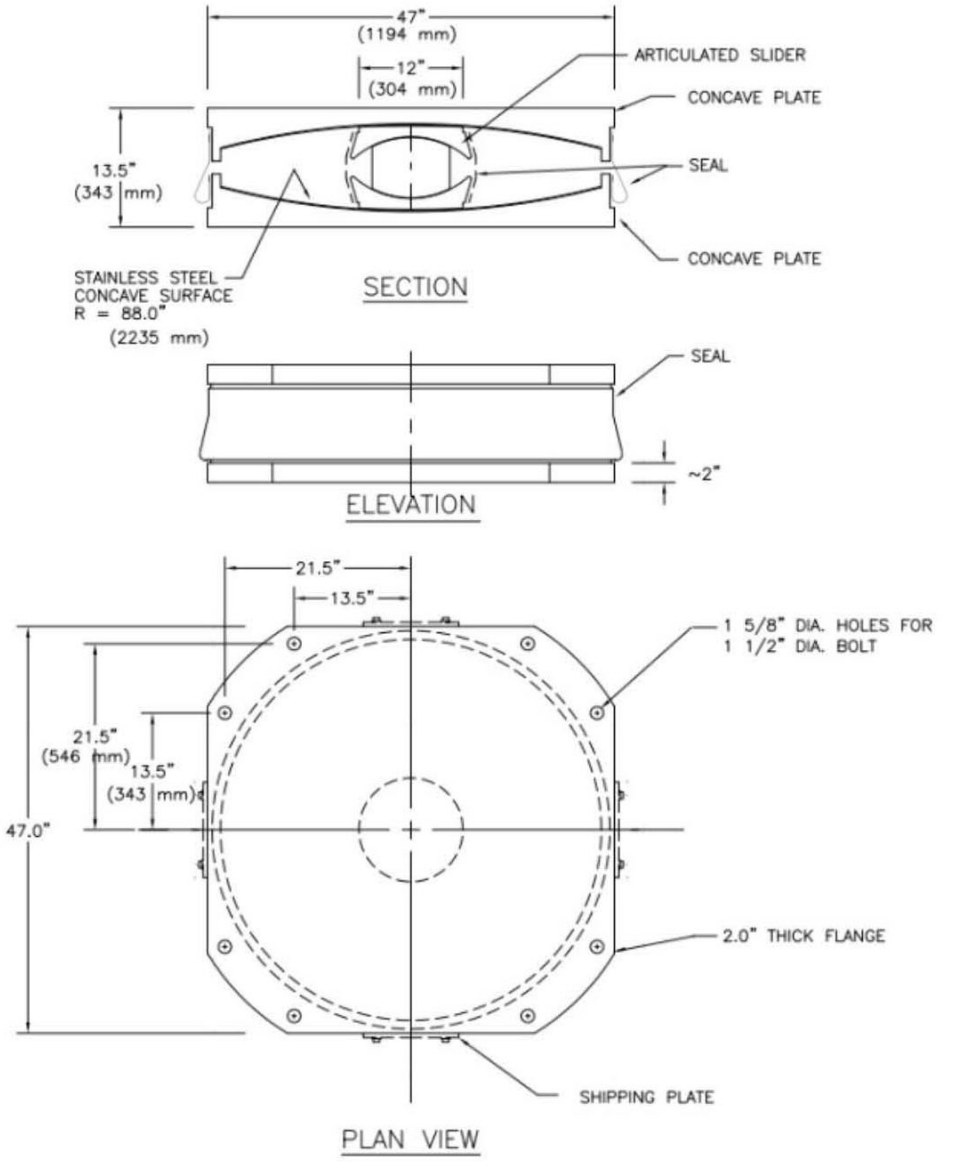
Cochran, Robert; Senior Structural Engineer and subject matter expert for 6980.03

Seismic Isolation of High Voltage Electrical Power Transformers; Technical Report; MCEER-16-0006; November 2, 2016

Shetab, Muneer; Standards Engineer and originator of 6980.03

www.earthquakeprotection.com

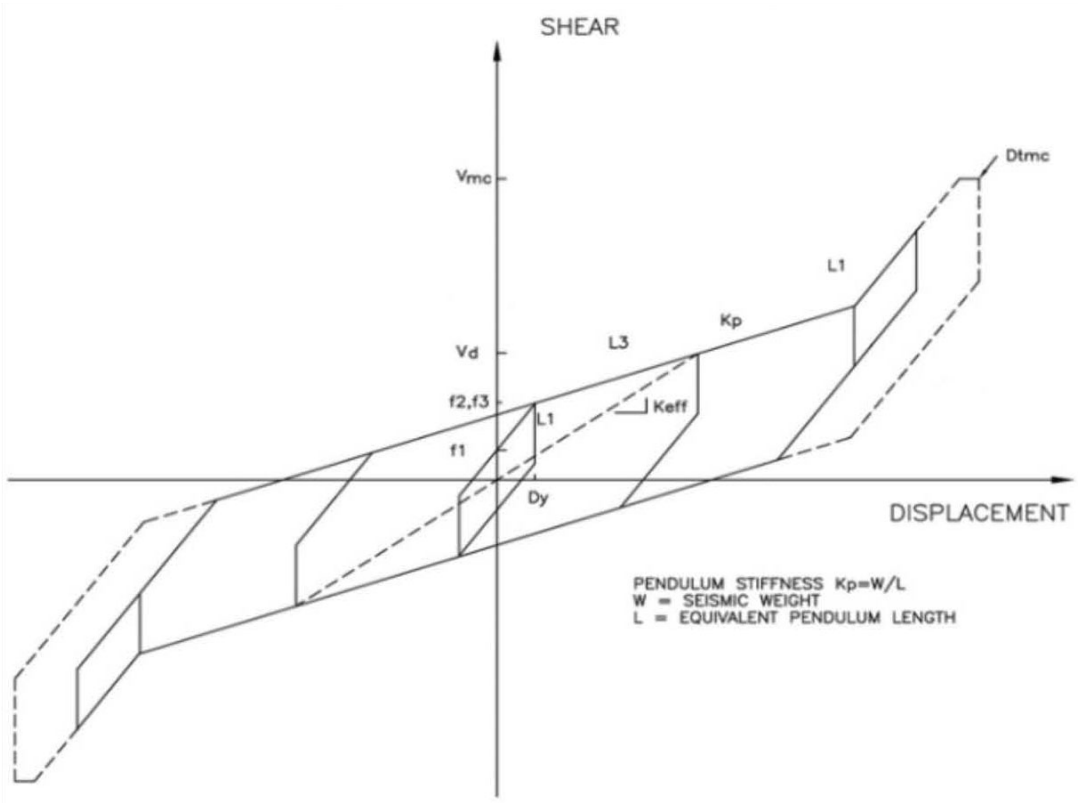
Appendix. A. Triple Friction Pendulum Isolator Dimensions, Typical



TOLERANCES:
1. PLAN AND HEIGHT DIMENSIONS AND TOLERANCES: ±3/8" (9.5 mm)
2. BOLT HOLE LOCATION DIMENSIONS: ±1/16"

EST. WEIGHT: 4060 LBS

Appendix B. Triple Friction Pendulum Isolator
Force Displacement Hysteretic Loop Diagram, Typical



FORCE DISPLACEMENT LOOP
AT QUALITY CONTROL TEST VERTICAL LOAD

QC TEST TOLERANCES
QC LOAD: 90kips (400kN) min.

AVERAGE ISOLATOR PROPERTIES

	f1	f2,f3
LOWER	0.02	0.115
UPPER	0.035	0.15

INDIVIDUAL ISOLATOR PROPERTIES

	f1	f2,f3
LOWER	0.015	0.110
UPPER	0.04	0.155

PENDULUM LENGTHS
L1=13"(330mm)
L3=167"(4229mm)

PENDULUM PERIODS
T1=1.2sec
T3=4.1sec

DISPLACEMENT CAPACITIES
Dtmc=36"(916mm)
Dmc=25.5"(649mm)

SHEAR STRENGTH CAPACITY AT QC LOAD
Vmc=65 kips (289kN)