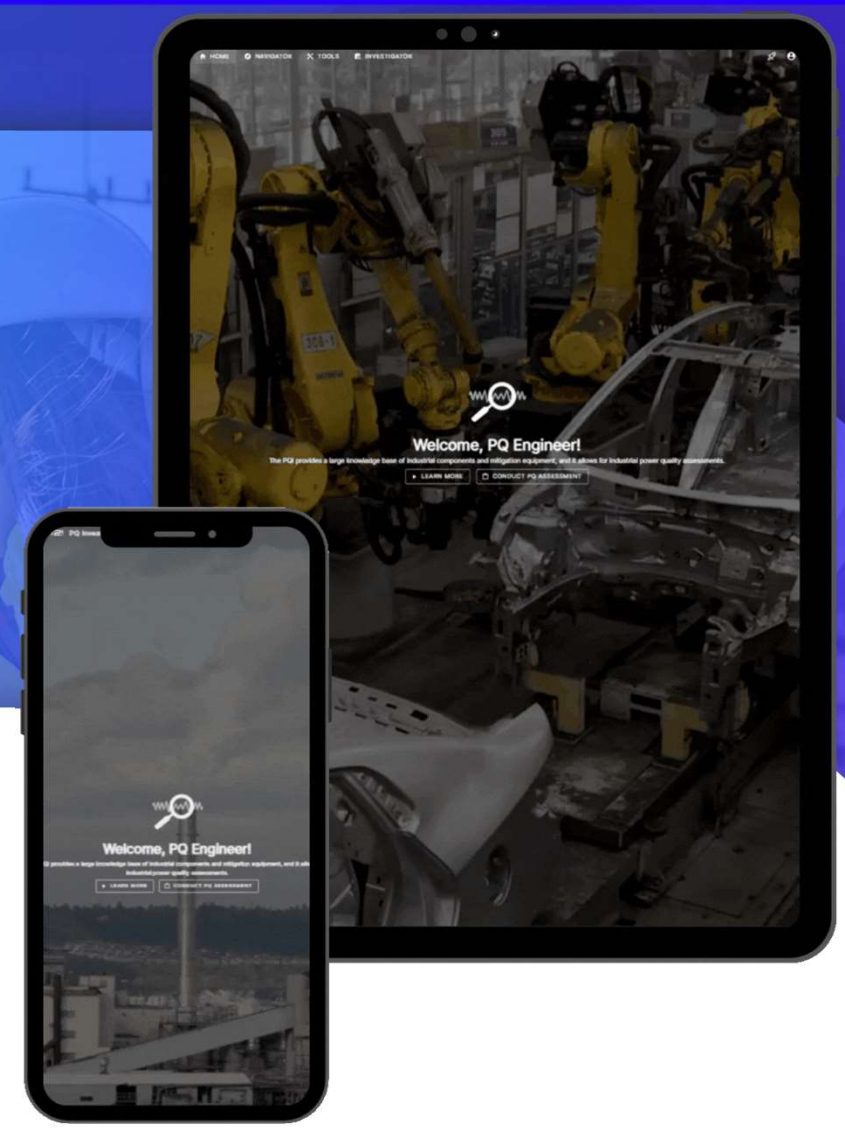
PQ Investigator Version 4.0 Workshop

June 10-12, 2024
PSE&G Edison Training & Development Center, 234 Pierson Avenue, Edison, NJ 08837, Room 120.



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Disclaimer

- This Slidedeck was organized from content generated from the PQI for use of August 22, 2024 PQI 101 Training Session
- The Navigator and Tools modules were designed by Mak Mckinney under the supervision of Eric Auel and Mark Stephens. All work unrelated to Mak has been omitted from this Slidedeck.
- Any usage of this slidedeck unrelated to understanding Mak's skillset is forbidden. The PQ Investigator is Copyright Product of EPRI (As is this powerpoint template) and therefore should not be used for any commercial activities.

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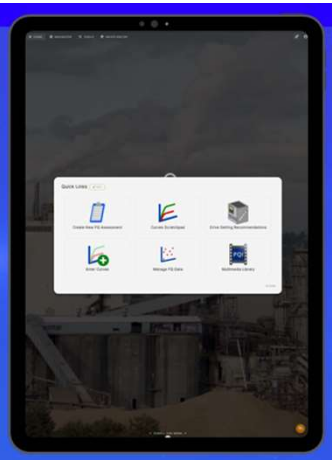
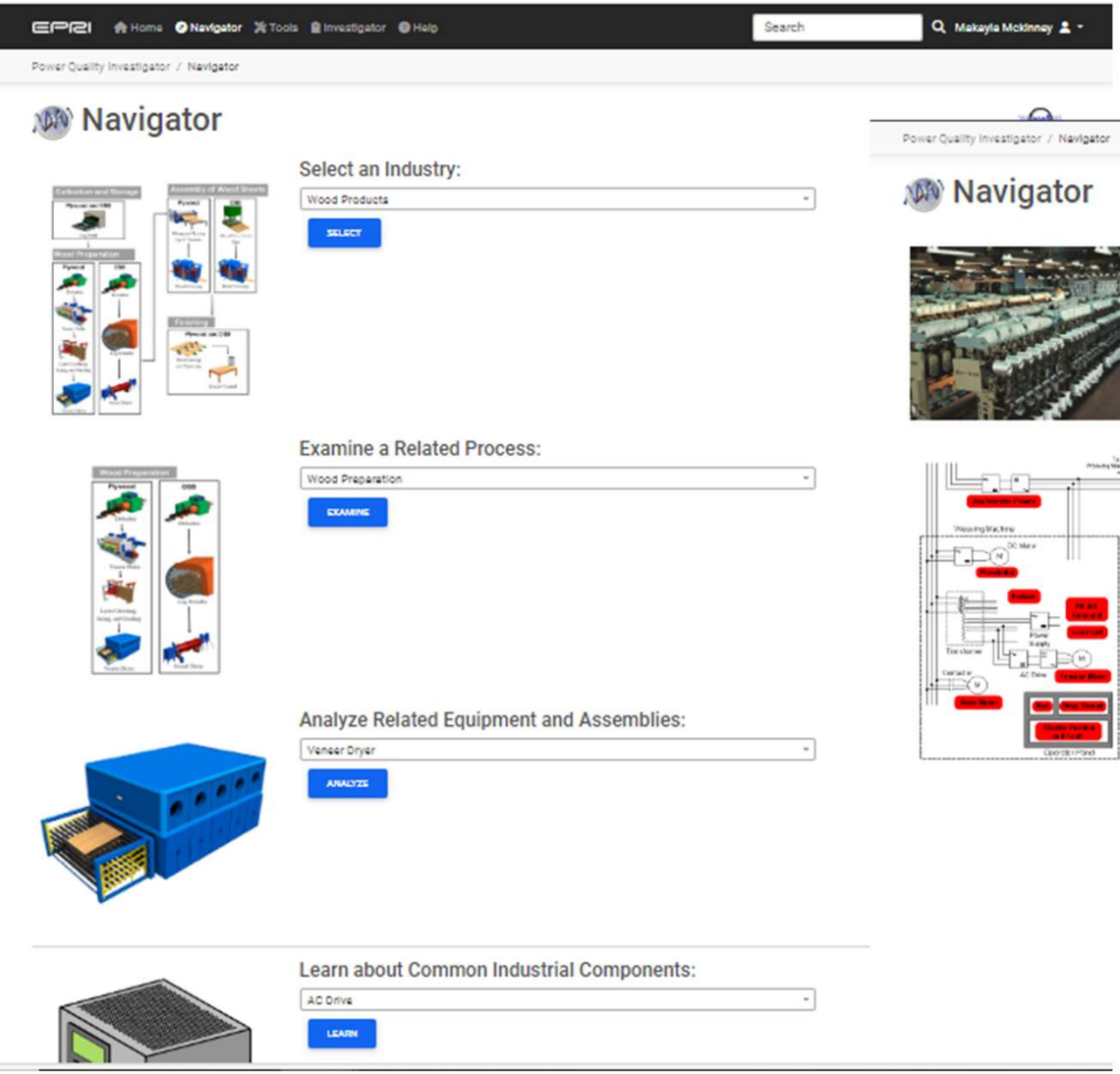
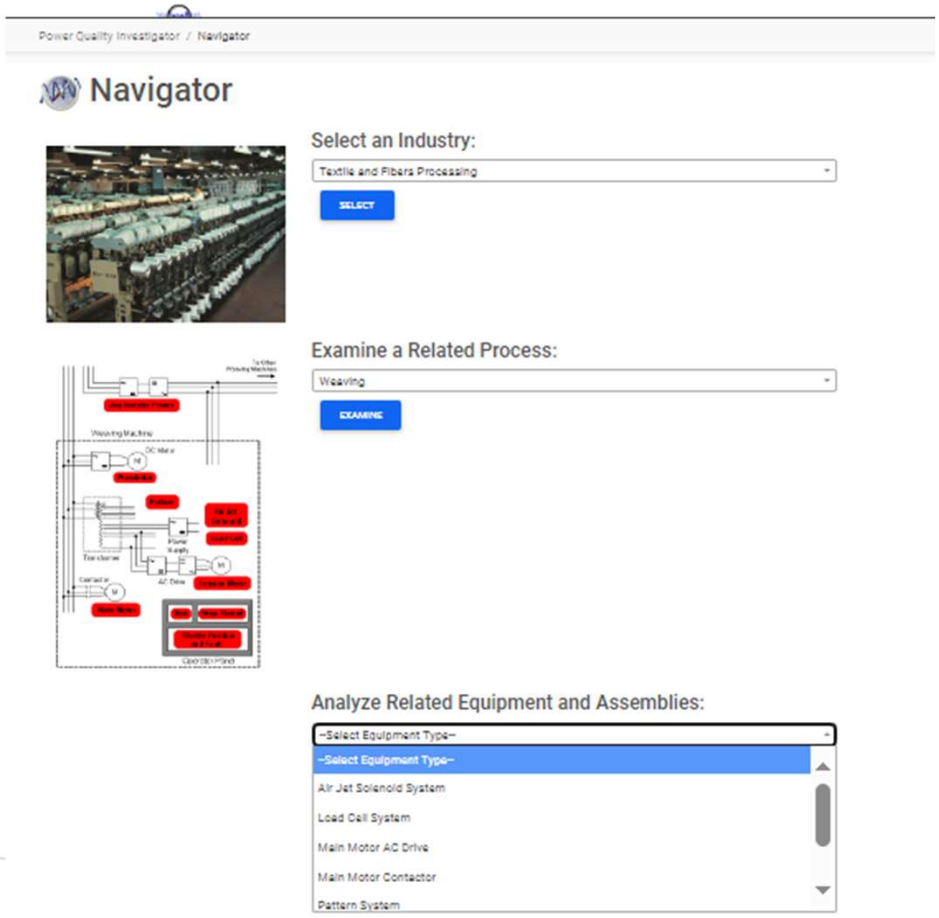


Introduction to the PQ Investigator

PQI Intro Video





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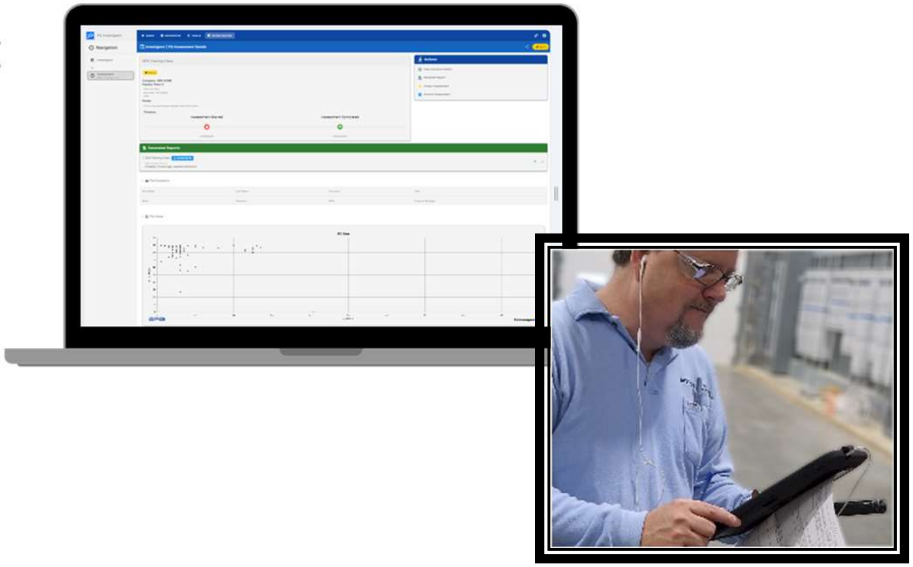
Power Quality Investigator and Users Group

- Access to the PQ Investigator expert tool at https://pqi.epri.com
  - Separate member company database areas
- Quarterly web training on features
- Use case findings based on field investigations using the PQ Investigator
- Collaboration forum for users to inform potential enhancements
- User support via Webex, telephone, and e-mail
- PQ Investigator Users Group meetings and workshops



DETAILS	CONTACT
$15k-$25k per year; Click here for more info Click here for Intro to PQI Video	**Mark Stephens** 865.218.8022 mstephens@epri.com

Leading Power Quality Software, Support, and Collaboration

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Introduction to the EPRI Power Quality Investigator

- It's a software tool, a robust knowledge base, a user group… and it's saving EPRI member utilities and their customers time and money while they are helping to improve it.
- The Power Quality Investigator, launched in 2008 under Program 1, is a software tool that captures EPRI's vast experience in investigating and solving end-user power quality (PQ) issues.
- Based on over 500 person-years of experience and hundreds of facility assessments, this expert system allows for expedited and thorough investigation, diagnosis, and documentation of end-use PQ issues.
- The PQ Investigator is also an ongoing annual supplemental project whose members comprise a user group that supports, maintains, and develops successive versions and enhancements of the software tool.

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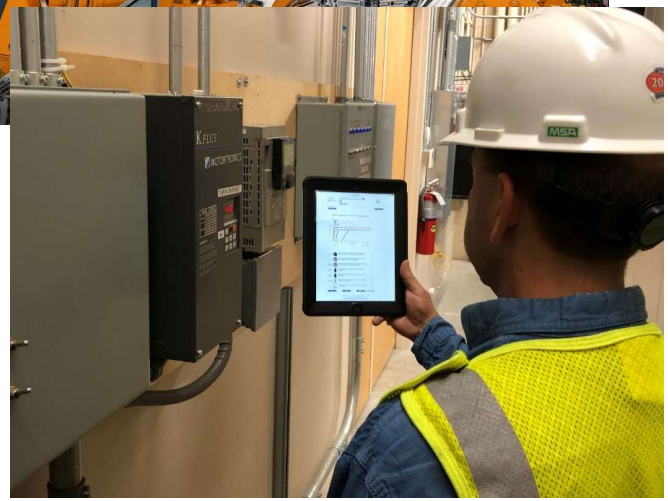
The Expert PQ Assessment Tool – The PQ Investigator

- EPRI developed and uses the PQ Investigator Tool when conducting PQ Facility Assessments.
- Through the PQ Investigator's Users Group Membership, this tool is available to you!
- Introduction to the PQ Investigator video is posted on mypq.epri.com at this link.



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PQ Investigator (PQI) Mission Statement

"The PQ Investigator will be the central tool for formulating client end-use mitigation strategies, for providing information to facilitate internal learning and client discussions, and for producing "editable" PQ Assessment reports to help solve customer PQ issues."

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EPRI's PQ Investigator Development Team

PQI Lead, Vision, Functional Specifications

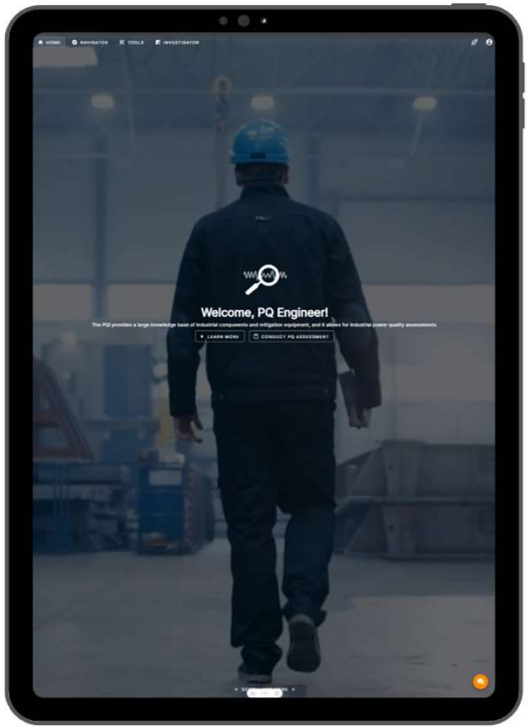
Mark Stephens, PE, CEM, CP EnMS
Program/Area Manager
PQ Services

Lead S/W Developer, Advanced Algorithms and Design

Eric Auel
Software Developer
Integrator/Roboticist
Advanced Algorithms
P1 Software
PQI Software

Sohan Birajdar
Associate S/W Developer
Advanced Algorithms
P1 Software
PQI Software

Makayla McKinney
Computer Engineering Student Programmer
PQI Software



PQI Users Group Members, Feedback from use of tool and Development of future Requirements and functionalities.

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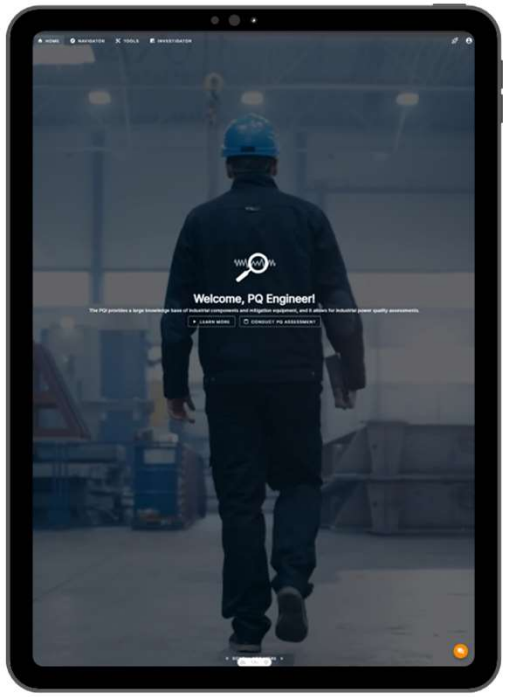
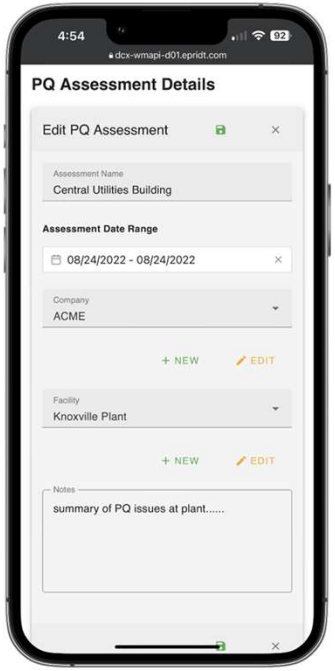
PQ Investigator Usage





Options:

1) Access site at https://pqi.epri.com

2) Use physical notebook approach in field and enter content when you can connect to the internet and go to the web site.

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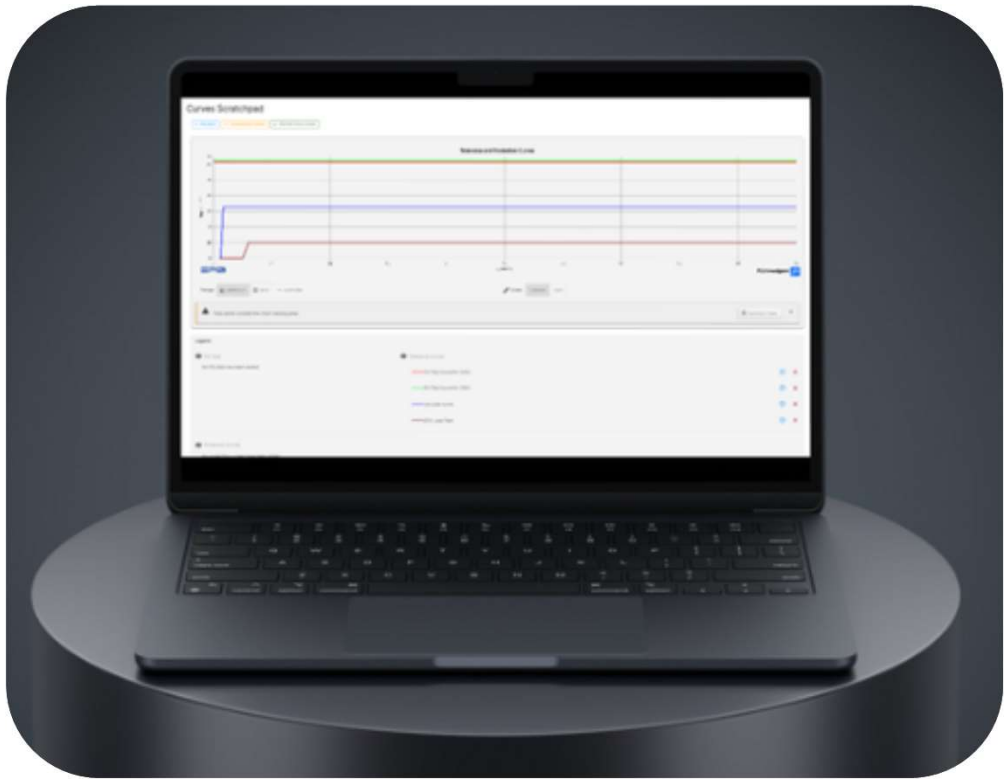
PQI Usage – Performing a Desk PQ Assessment



- With the PQ Investigator, your can gather info and show problem and solution from your Desk!
  - Import PQ Data
  - What's in your cabinet?
    - Ask or have them send you a list of cabinets and contents
    - Select and plot out
    - Pick mitigator option
  - Quick - Screen Grab into PowerPoint or Word
  - Thorough – use Investigator module to create a report and send to customer

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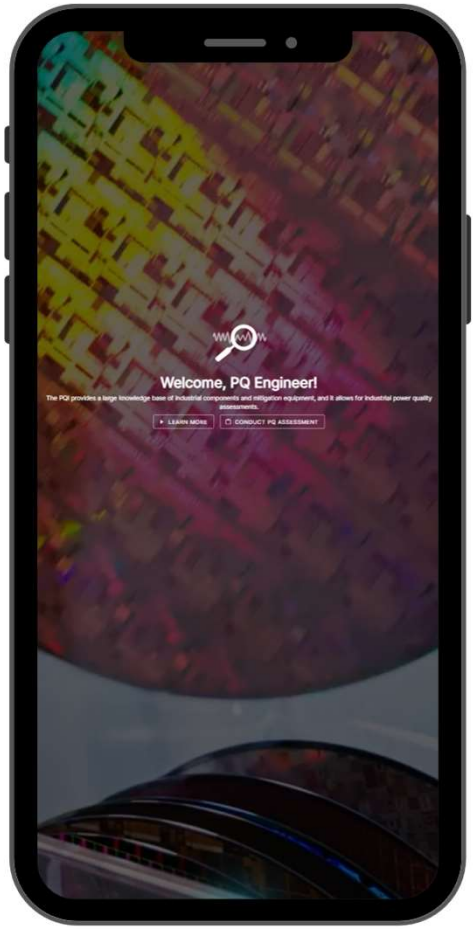
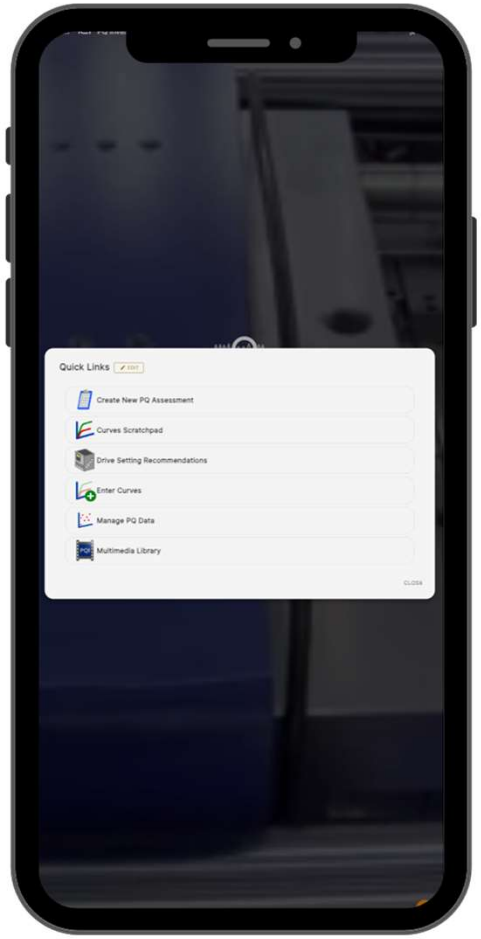
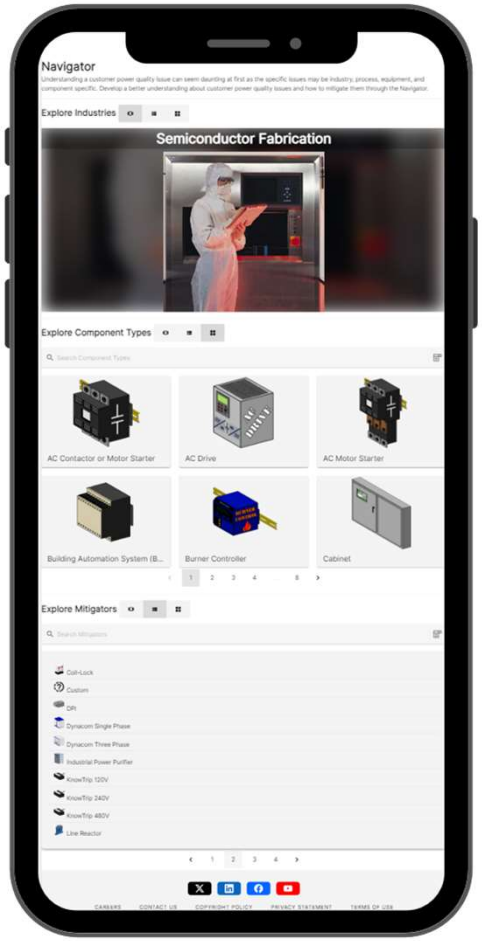
Using PQ Investigator on Smartphone and Tablet







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Initial Vision

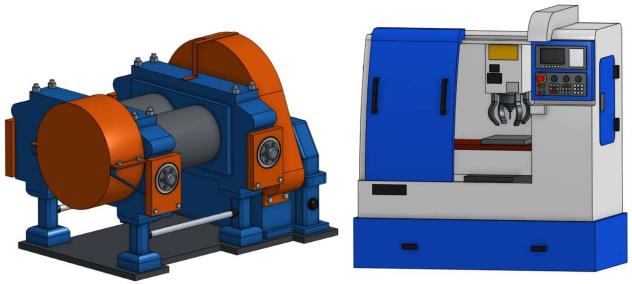
- What if you could…
  - capitalize on EPRI's knowledge base?
  - learn about customer processes in advance?
  - solve many customer PQ issues internally?
  - find the information you need to inform the customer of solutions?
  - conduct your own PQ assessments using EPRI's knowledge base?
  - create useful PQ assessment reports by …
    - an on-site plant assessment OR
    - solving the problem from your desk!

How to I learn from hundreds of previous EPRI PQ Assessments?

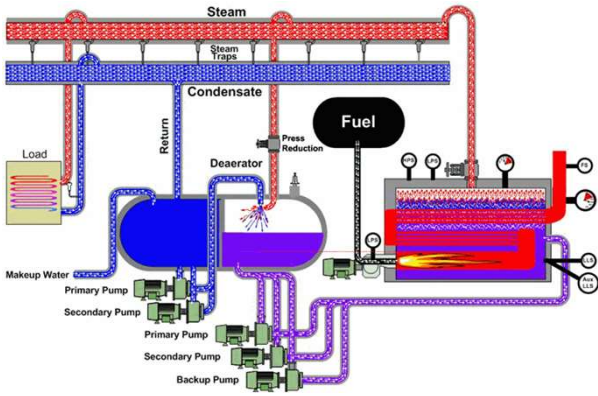
Site Investigations 1996-2021		
Industry	Sites	Percentage
Semiconductor	39	11.4%
Plastics	32	9.4%
Food & Beverage	38	11.1%
Automotive	34	10.0%
Paper/Printing/Wood Products	30	8.8%
Aviation/Aerospace	14	4.1%
Medical/Hospital	16	4.7%
Machining	12	3.5%
Fibers/Textile	14	4.1%
Chemical	13	3.8%
PetroChem & Nat Gas	14	4.1%
Metals/Wire	17	5.0%
Glass	10	2.9%
Commercial	8	2.3%
General	12	3.5%
Heavy Ind	9	2.6%
Pharma	8	2.3%
Govt	9	2.6%
Electronics	7	2.1%
Mass Transit	1	0.3%
Data Center	1	0.3%
Power Gen/DG	3	0.9%
Total Sites	341	

How do I find EPRI publications on the customer issue that can help inform them?

How do I understand the PQ Issues with these Machines?



What are the specific PQ vulnerabilities of this process?



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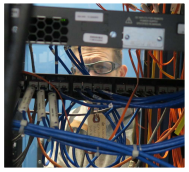
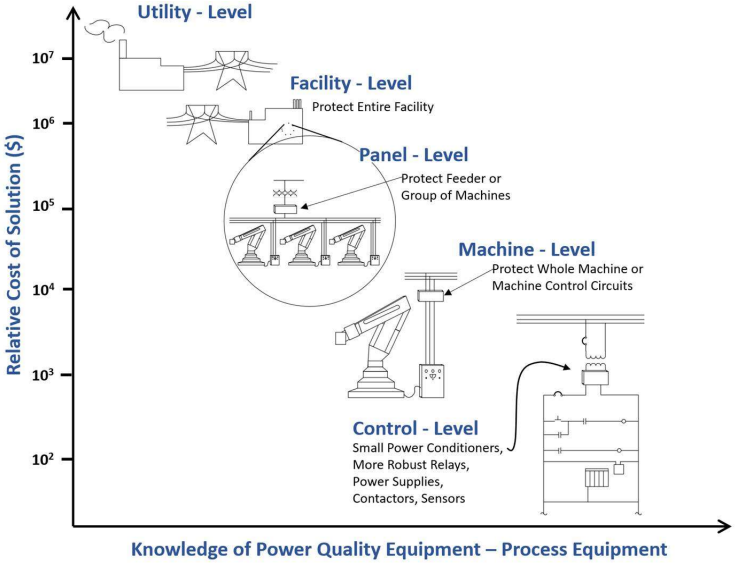
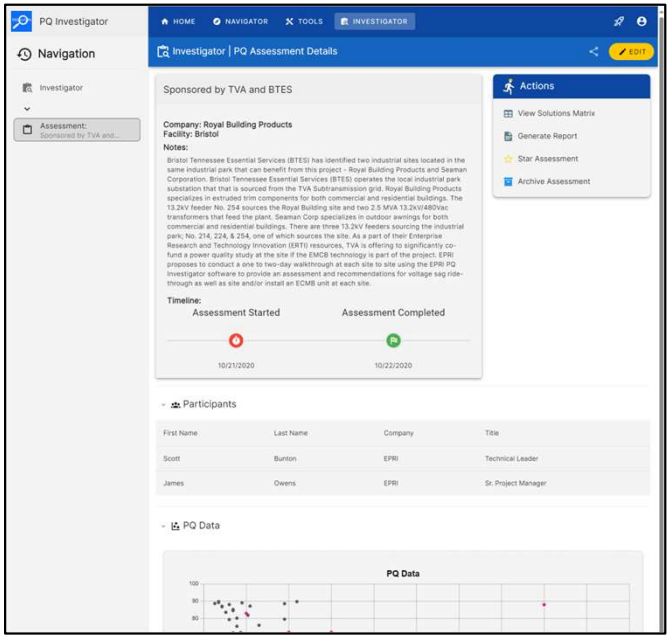
PQI's "EPRI Knowledge Base" Integrated Into Expert Tool





In-Depth Knowledge of Solutions



Integrated into Expert PQI Tool

Enables Precision Recommendations

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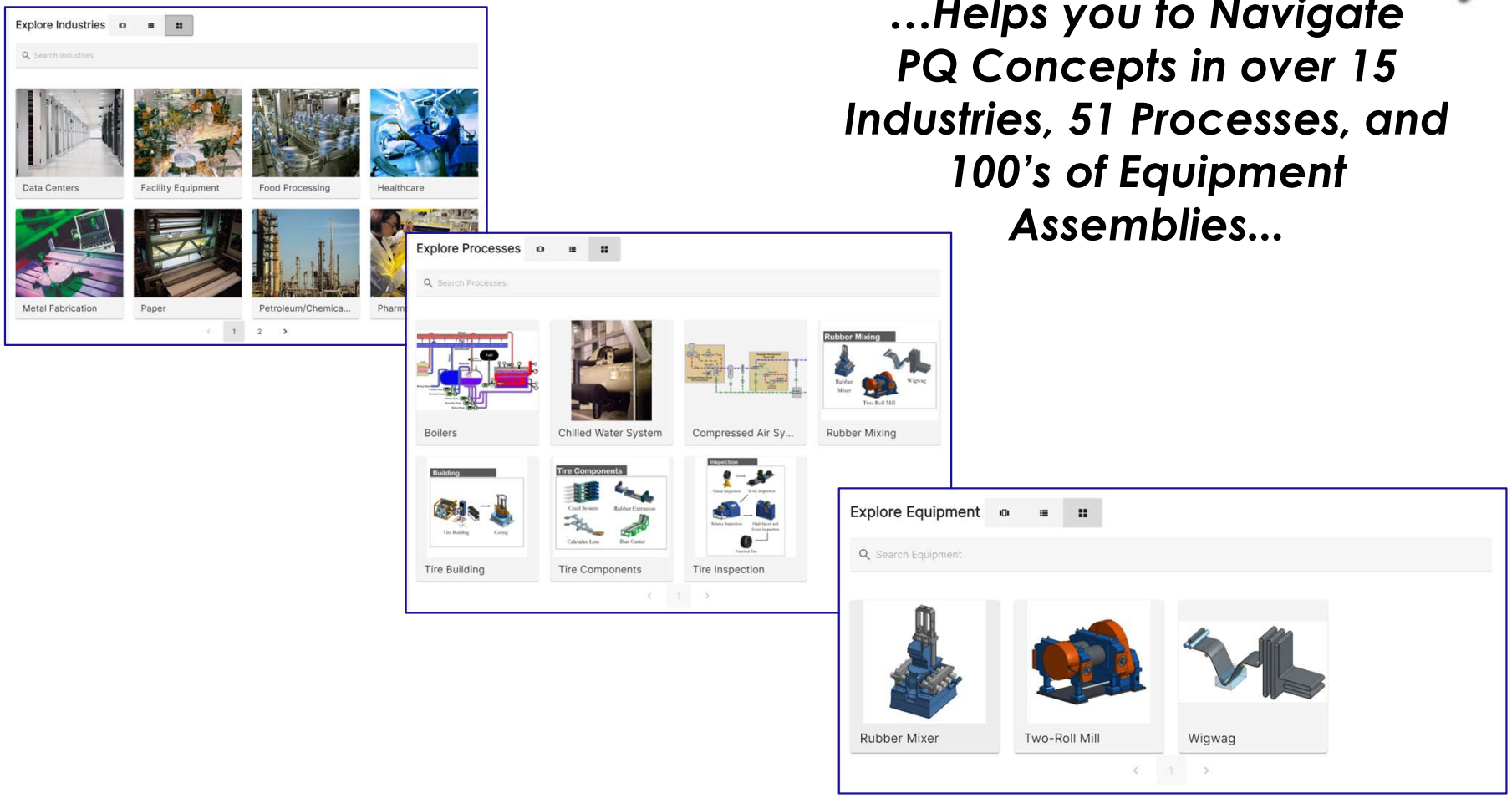
The PQ Investigator …



…Helps you to Navigate PQ Concepts in over 15 Industries, 51 Processes, and 100's of Equipment Assemblies…

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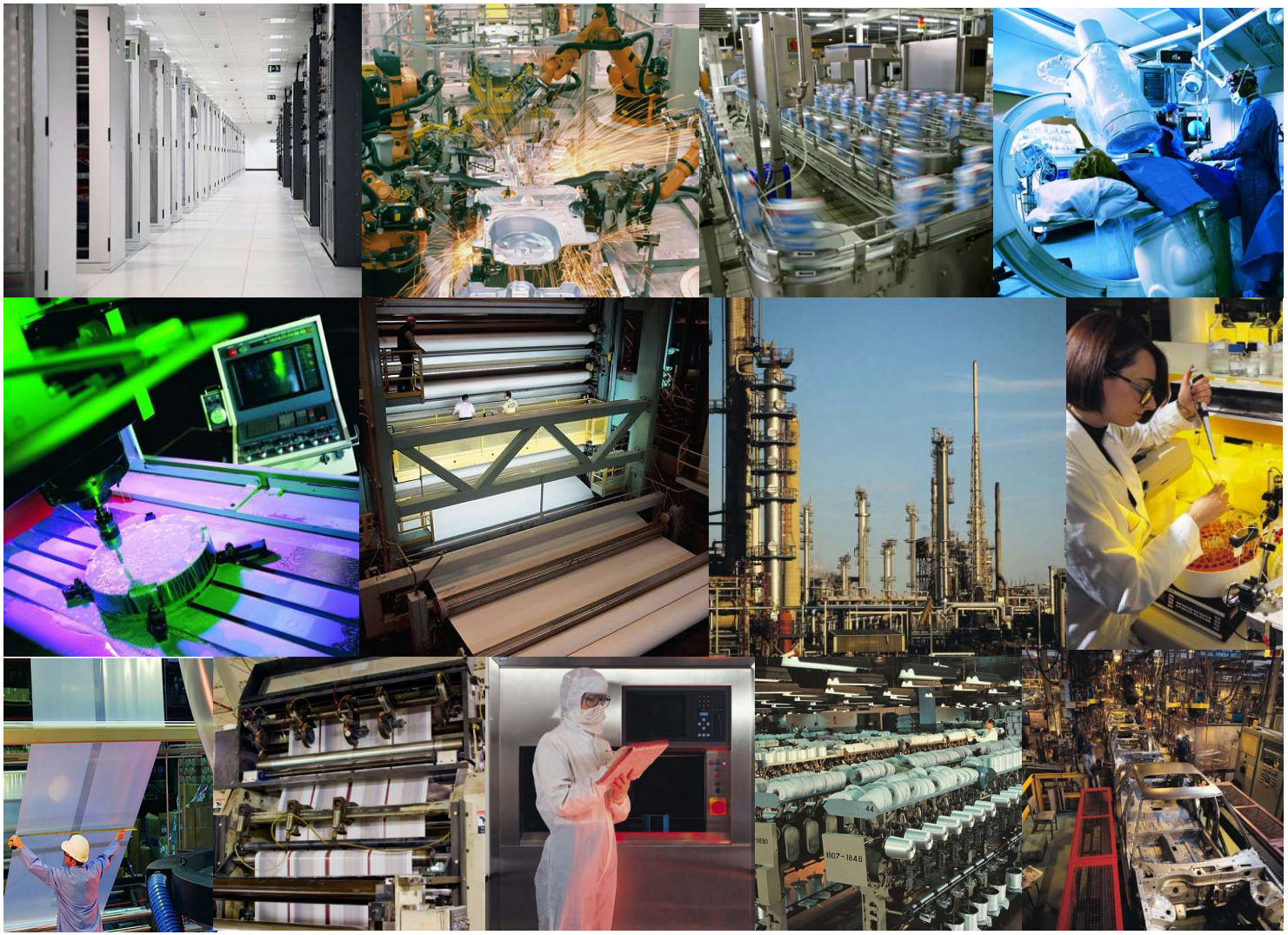
Industries:

- Data Centers
- Facility Equipment
- Food Processing
- Healthcare
- Metal Fabrication
- Paper
- Petroleum/Chemical Processing
- Pharmaceutical Manufacturing
- Plastics
- Printing and Publishing
- Semiconductor Fabrication
- Textile and Fibers Processing
- Tire Manufacturing
- Transportation
- Wood Products
- Primary Metals (pending)
- Food Processing (pending)



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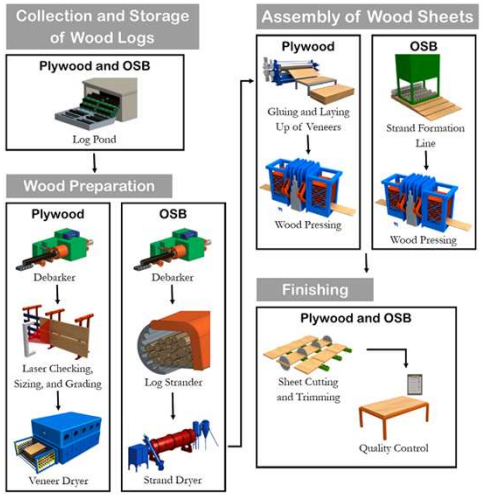
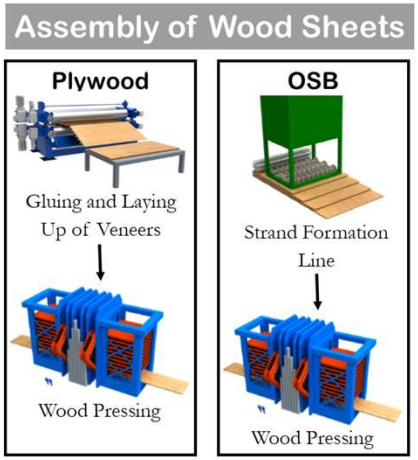
New Industries Continually Added: Wood Products

Industry

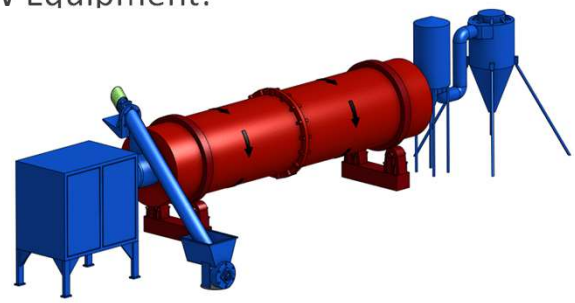


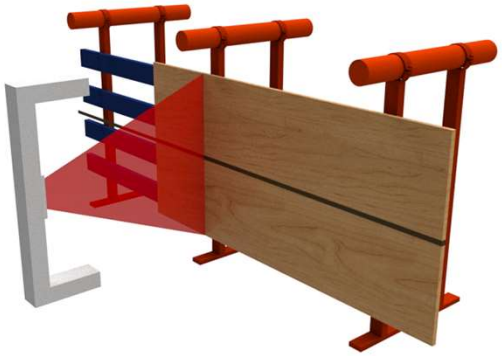
Process

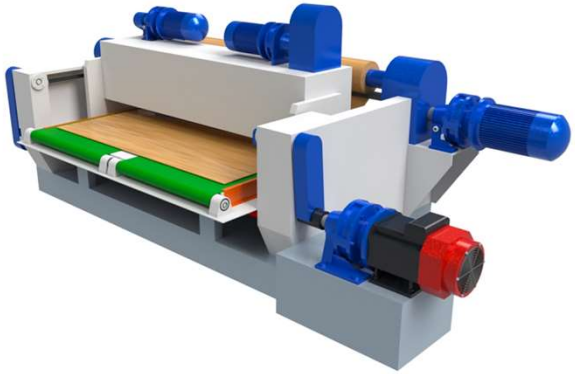


Equipment

New Equipment:







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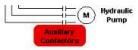
… integrates “How its Made” videos in many industries and Processes (within PQI webpages)

Navigator

Power quality issues in the tire manufacturing industry can cause tires to be mal-formed, unbalanced, and not structurally sound. With boilers being critical to the curing process, power quality issues can lead to tires having a shallow tread depth. Mal-formed tires cannot be used on the road, contributing to revenue loss for the industry.



Boilers may be used to produce steam used directly in industrial processes such as a paper plant. These boilers may use energy supplied by the electrical utility, by natural gas or other fuel suppliers, or from waste by-products made at the industrial facility or transported to the facility from other sources. This last case may allow a co-generation process where the steam generated using these waste products may not only be used directly in a manufacturing process but may also be used to generate electricity on site.

Screen Printing
Approximately 3% of market
Specialized technique using fine silk, nylon, or steel screen
Screen has stencil of image
Ink is pushed through the screen
Cost-effective method for printing on mugs, key chains, and on t-shirts

Semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor processing equipment is especially vulnerable to voltage sags. If equipment goes down temporarily the entire process may have be restarted and materials discarded. This can be extremely expensive in this industry so good power quality is imperative.

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…helps you understand over 40 different types of industrial components and their PQ susceptibilities against your PQ Data (nearly 1000 ride-through curves!)

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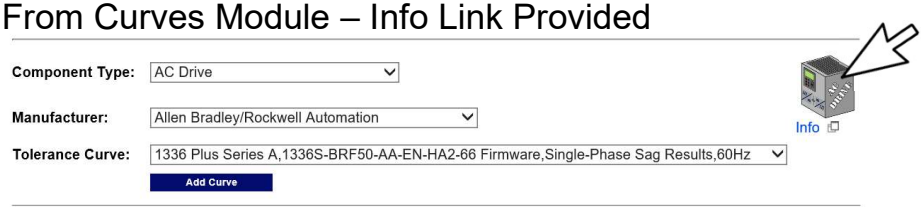
…integrates Cut Sheets for components in database

Tools .: Curves :

Manufacturer

- Users requested way to understand component selected.
- 530 of 566 Components now have cut sheet links
  - (Remainder too old to find on Internet)

From Curves Module – Info Link Provided



By Manufacturers List from Search – Info Link Provided

Opens New Page and Displays

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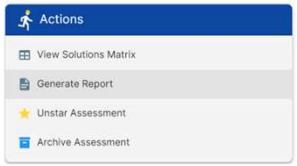
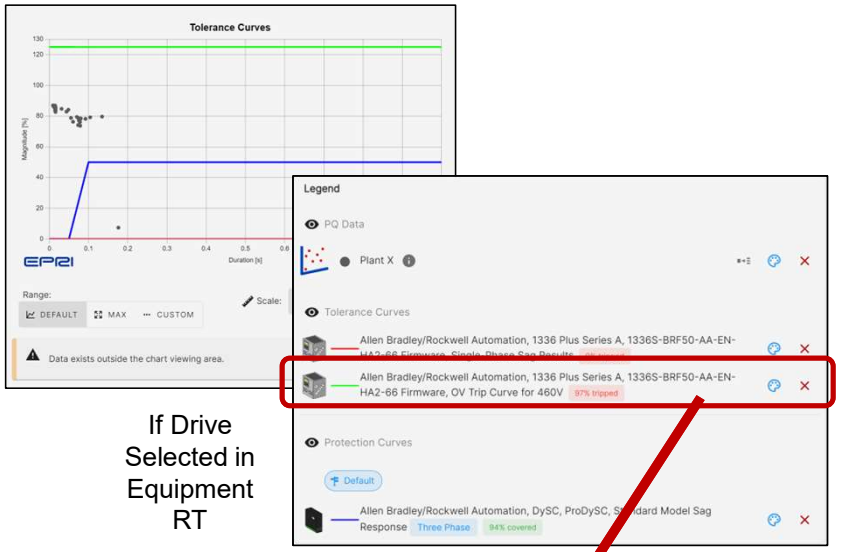
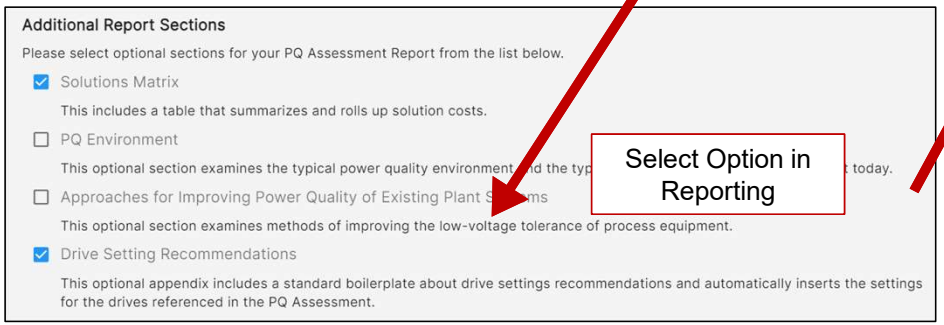
…includes automatic integration of drive parameters upon selection…



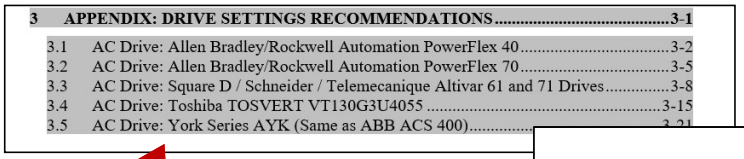


If Drive Selected in Equipment RT

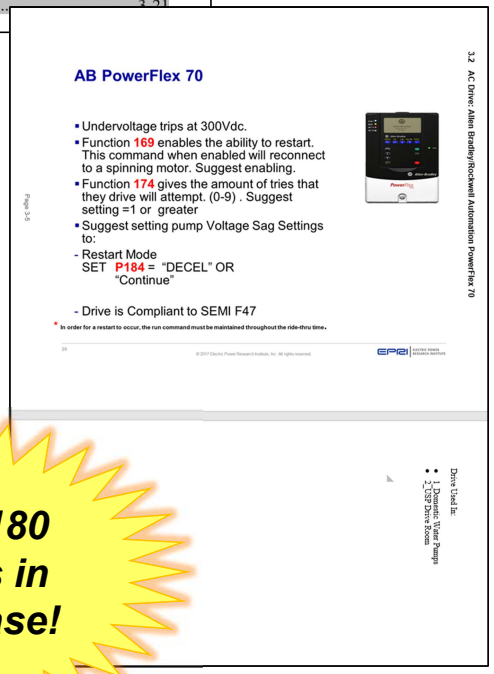


Select Option in Reporting

Included in Report TOC



Appendices



Over 180 Drives in Database!

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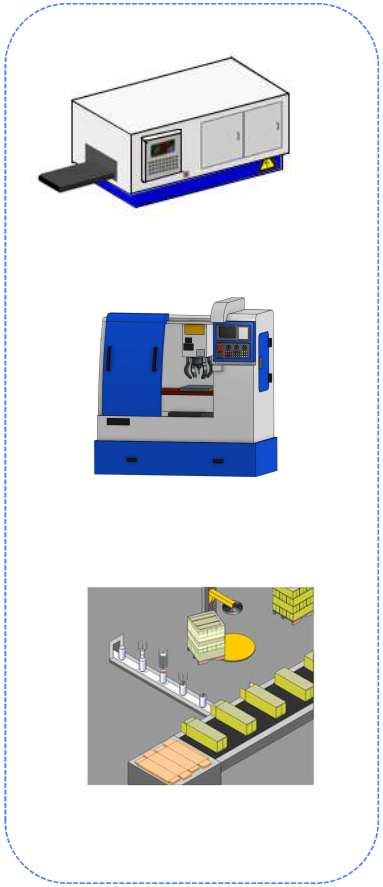
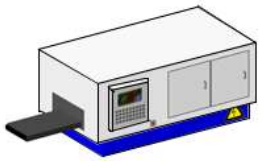
…Enabling an engineer to create virtual PQ model…

Area B
"Machining Line 1"



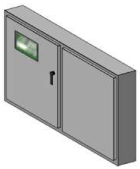
Equipment

Equipment B1
"Nakamura 100"

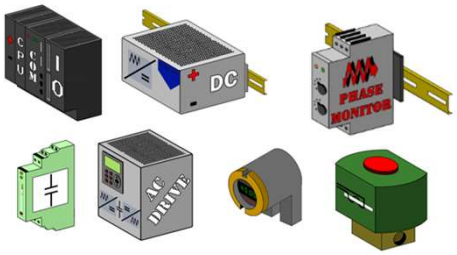


Equipment B2
"Staley 440Z"

Equipment B3
"Conveyor Panel"



Components (Curves)



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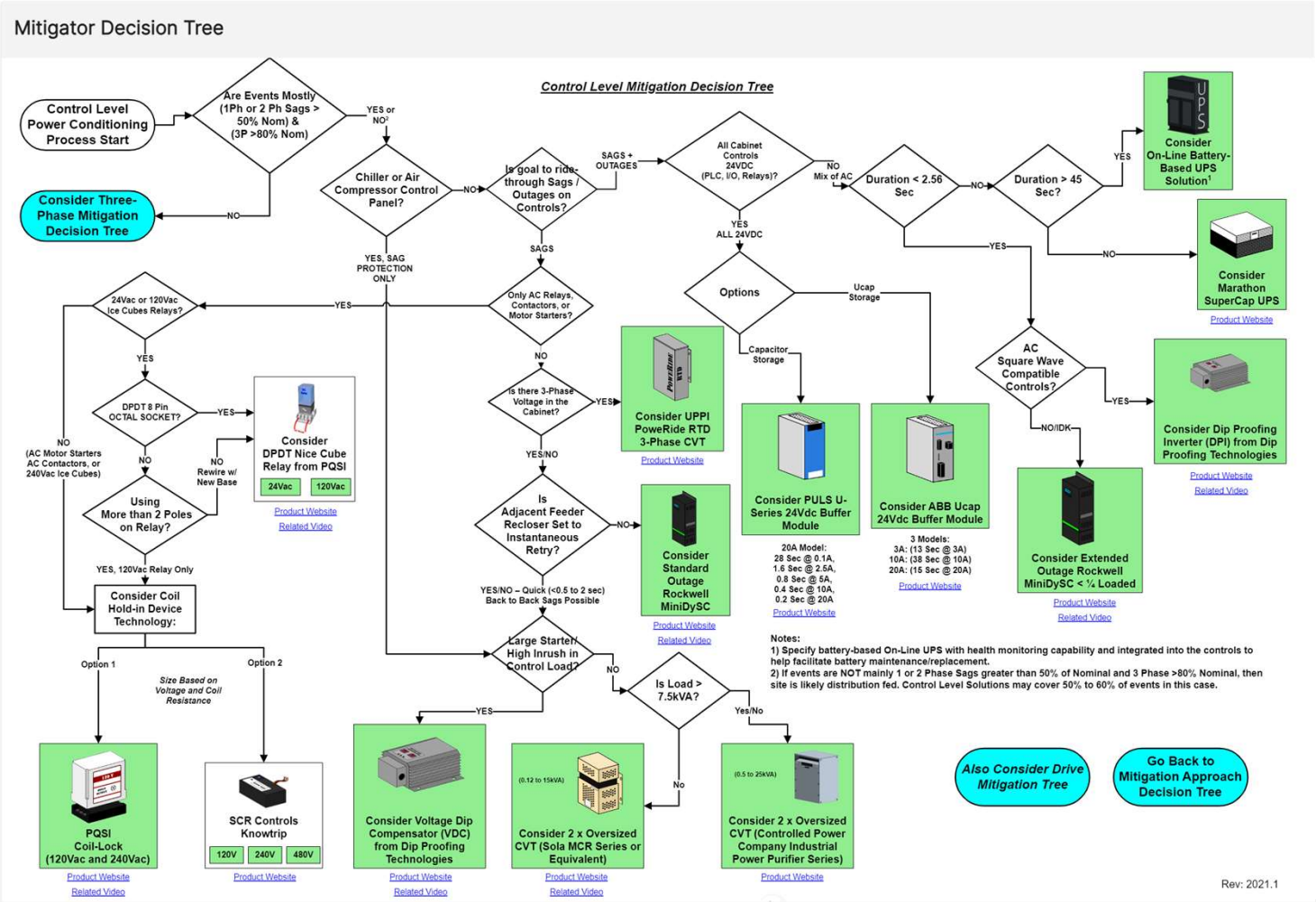
… And Identify Actionable Mitigation Strategies at multiple levels to solve PQ problems…



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… And Determine the Effectiveness of the Solution …

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MM0

Manufacturers

- Allen Bradley
- Bonitron
- CAT
- Dip Proofing Technologies
- Marathon Power
- Omniverter
- PQSI
- SCR Controls
- Sola
- UPPI

Model Categories

- AVC
- Battery-Based UPD
- Capacitor-Based UPD
- CLEANSOURCE
- Coil-Lock
- CVT
- DPI
- Know Trip 120V
- Know Trip 240V
- Know Trip 480V
- MegaDySC
- MiniDysc
- Nice Cube Relay 120Vac
- Nice Cube Relay 24Vac
- PoweRide RTD
- ProDySC
- Sag Ride-Through UPD
- SuperCap UPS
- Ultracapacitor-Based UPD
- VDC

… Utilizing Built-in List Price and Spec Data …

Over 821 Mitigator Products Listed with Part Number, Specs, and List Price!

NAVIGATOR | TOOLS | INVESTIGATOR

Mitigator Specifications and Pricing

Select Mitigator

Mitigator Costs

Select a Mitigator from the dropdown above to view its costs.

MITIGATOR DECISION TREE PDF

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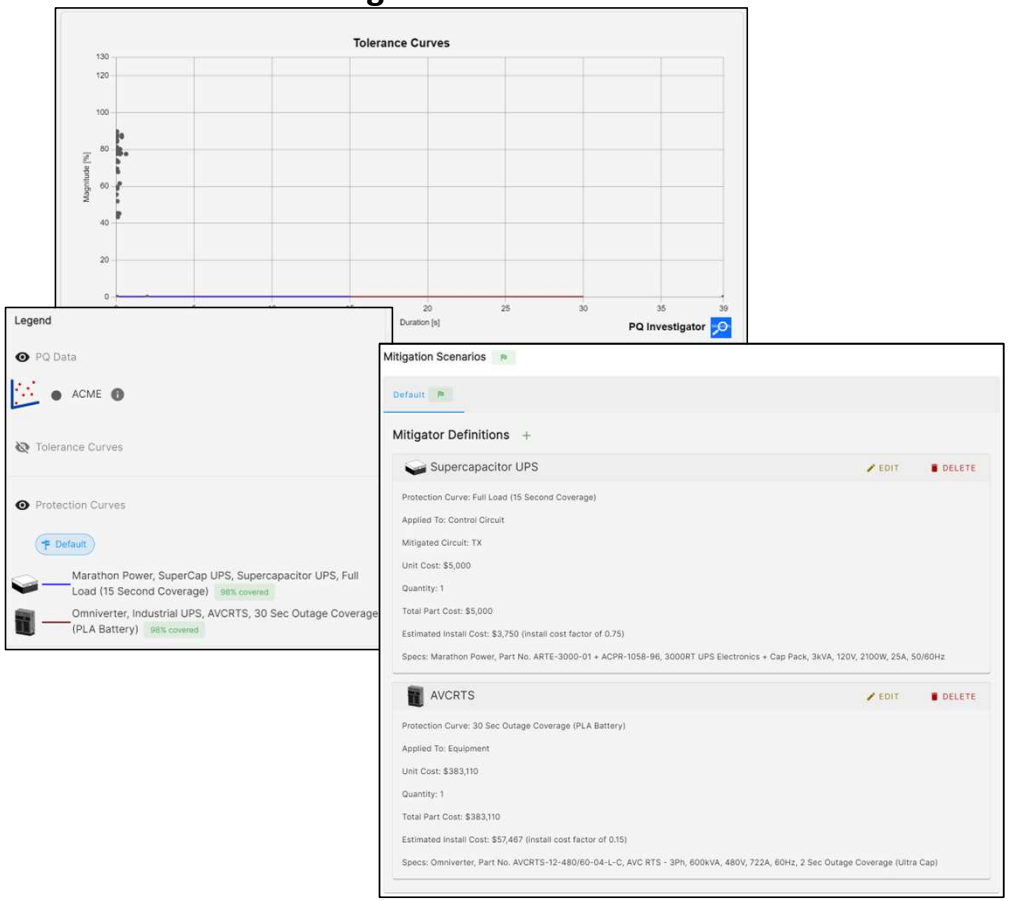
Slide 25

MM0 Updates Made:
1. Replaced "509" Mitigators with "821" Mitigators
2. Changed CAT UPS To be CLEANSOURCE

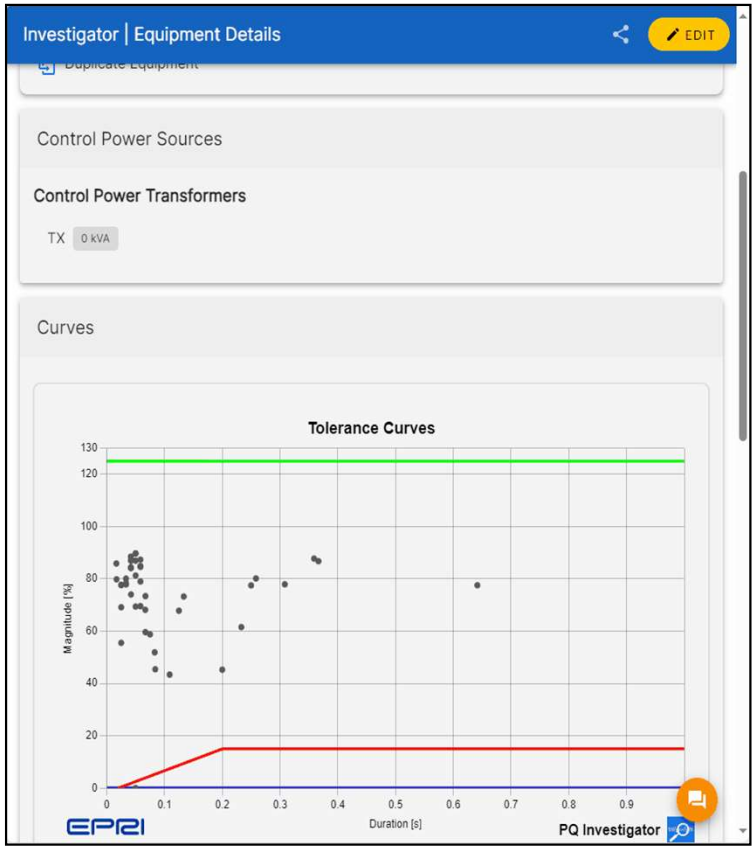
Mckinney, Makayla, 2024-07-24T12:01:23

… That allows for Sizing and Specifying A Mitigator…

First Create RT Curve in Equipment and Select Mitigation



Next Define Mitigator, Apply to Proper Circuit, and Pick Unit from List!



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… Including Economics of Implementation…

Solutions Matrix

Overview

This page provides a **solutions matrix**, a valuable aid in determining which solutions are most profitable and feasible, based on equipment sensitivity and budget constraints for implementation of mitigation.

In this context, **estimated sensitivity** refers to the percentage of power quality events - *occurring between 0 and 200 milliseconds* - that could potentially cause any given equipment to momentarily trip and consequently shut down. Estimated sensitivity is based on individual component sensitivities within each equipment. A higher percentage implies that the equipment is generally more sensitive to power quality events.

In the solutions matrix below, higher-sensitive equipment is denoted by orange and red boxes, while less-sensitive equipment is denoted by green or yellow boxes. For example, a given equipment with an estimated sensitivity of 65% would be classified as *High* sensitivity, as it is included in *SARFI 70* but not *SARFI 80*.

Total Solution Costs

Mitigator Scenario	Total Cost
Default	$3,200

Breakdown by Area

Building 2 Lab

Cost Details by Equipment

Equipment	Historical Trip Percentage	Estimated Sensitivity	Default Cost
3D Printer	25%	45%	$3,200

Items per page: 10 1-1 of 1

Total Costs for Area

Mitigator Scenario	Total Cost
Default	$3,200

Simple Payback Analysis

Net Investment

One-Time Capital Outlay: $3,000

Installation Cost: $2,250

Net Investment
= One-Time Capital Outlay + Installation Cost
= $3,000 + $2,250
= $5,250

Net Annual Return

Estimated Downtime Cost (per Year): $10,952

Percent Events Covered By Solution: 87%

Annual Benefit
= Estimated Downtime Cost * Percent Coverage
= $9,528

Ongoing Annual Expense: $250

Net Annual Return
= Annual Benefit - Ongoing Annual Expense
= $9,528 - $250
= $9,278

Simple Payback: 6.79 months (0.6 years)

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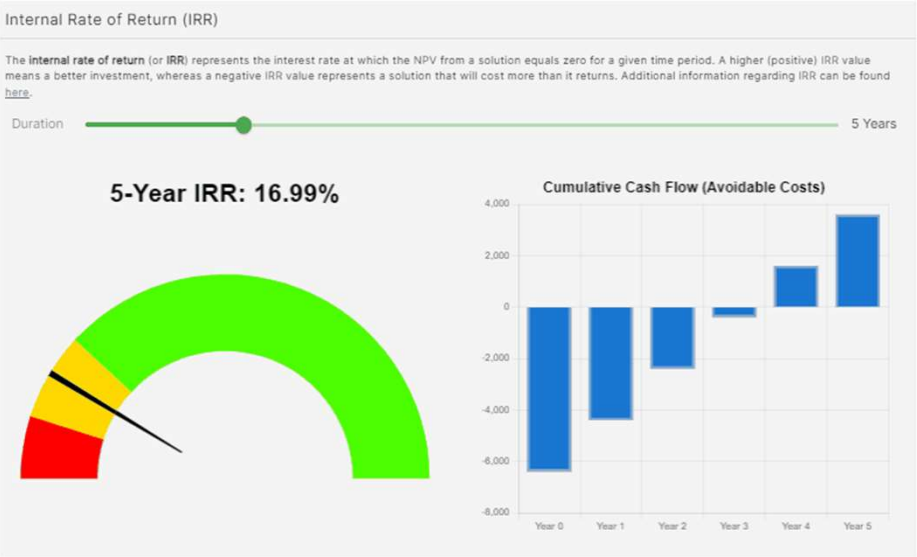
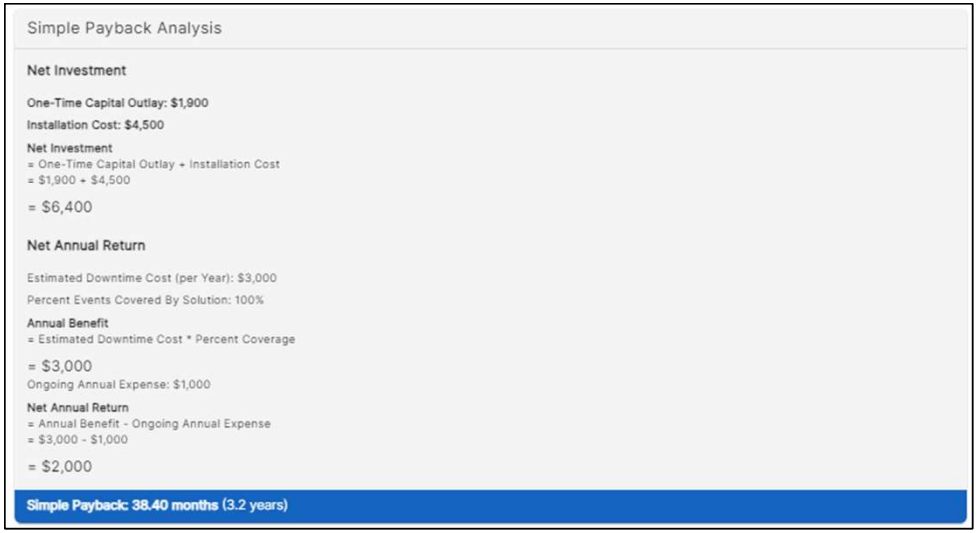
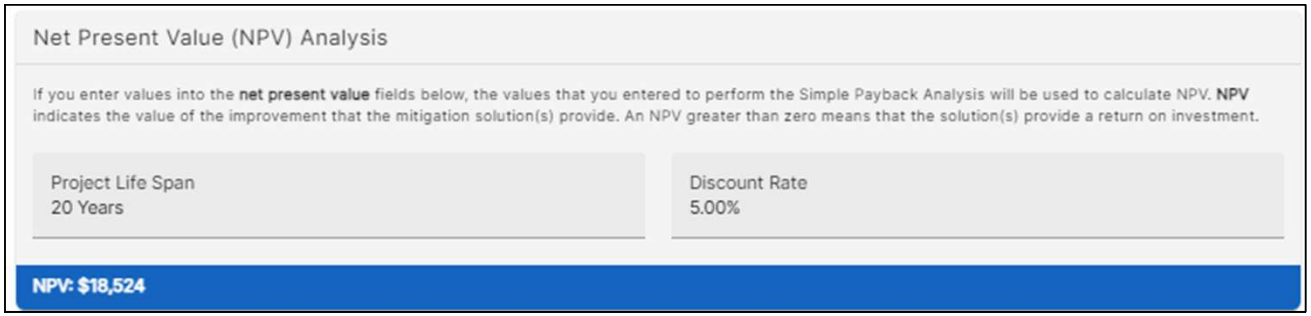
MM0

… and Calculation of Payback, Net Present Value, and IRR







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Slide 28

MM0 2

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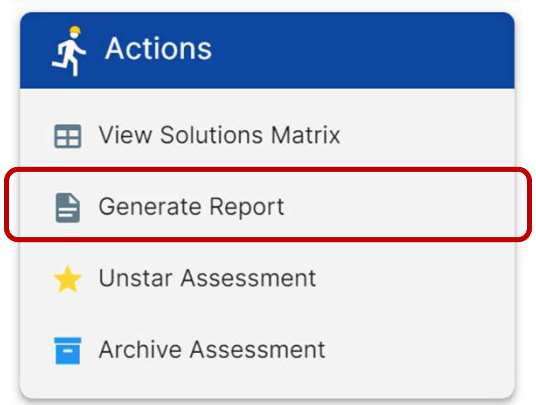
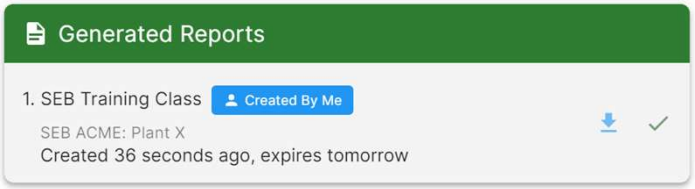
… Enabling Detailed Recommendations for customer through a robust Reporting Engine…





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… Enabling Detailed Recommendations for customer through a robust Reporting Engine…

Richmond Plant - Fareva
PQ Audit Report

Prepared for:

Fareva

Prepared by:

EPRI

And EPRI's

Power Quality Investigator 3.2 Beta

November 1, 2018

EPRI PQ Investigator: Richmond Plant - Fareva Power Quality Audit Report

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Power Quality Investigator 3.2 Beta
Electric Power Research Institute (EPRI)
3420 Hillview Ave.
Palo Alto, CA 94304

i

EPRI PQ Investigator: Richmond Plant - Fareva Power Quality Audit Report

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Right-Click Here and Select Update Field to Refresh the Table of Content

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EPRI PQ Investigator: Richmond Plant - Fareva Power Quality Audit Report

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…With User Driven Prioritization …

*** 2021 PQI UG Prioritization Survey ***

Part 1: Items We Plan on Implementing for Spring 2021 Release and the Year as a Whole

Item	New Feature	Details
E1	Create new admin database interface tool to allow for live database updates	Planned 2021
E2	Add new Industries (Utilities, Rolling Mill, Food Processing)	Planned 2021
E3	Continue Development of PQI Web Service	Planned 2021
E4	Enable Generalized Reporting for Primary-Fed Customers	V3.5, Spring 2021
E5	PQ Data Workflow Improvements in Curves Module	V3.5, Spring 2021
E6	Curve Module Enhancements	V3.5, Spring 2021
E7	Interactive Mitigation Trees	V3.5, Spring 2021
E8	Automatic Plotting of Three-Phase Mitigation Data	V3.5, Spring 2021
E9	Enable Site-Wide Filterable Dropdown Controls	V3.5, Spring 2021
E10	Economics Module Calculation Enhancements	V3.5, Spring 2021
I1	Develop Functional Specification for PQView Data Set Connections	Spring 2021

*** 2021 PQI UG Prioritization Survey ***

Part 2: UG Prioritization of Remaining Items to Execute First (V3.6)

Item	New Feature	Execute First (Check up to 10)
E11	Add more components, drive RT Curves	☐
E12	Add ability to import CSV files from other formats (Pqube, Pqube3)	☐
E13	Add/Update Latest presentations from training courses	☐
E14	Add DER sensitivities for equipment already in the field (inverters, etc)	☐
E15	Add Quantity Column to the cost summary tables	☐
E16	Show both internal PQI and external (EPRI) document search results	☐
E17	Add Tree View of Navigator Module	☐
E18	Where available, use EPRI video hyperlinks within report	☐
E19	Add SARFI x filtering of data like IEEE1668 or SEMI F47	☐
E20	Bug Reporting, Tracking, and Feature Requests	☐
E21	Add Surge Protection as a Mitigation Category and Device	☐
E22	Roll additional harmonics data sets into PQI from P1.008 Testing and PANDA Database	☐
E23	Add Utility Mitigation Strategies (Pilot Relays, Arrestors, Ref: IEEE 1409, MyPQ: Grid Side Solutions, PQ in Transmission and Distribution)	☐
E24	Add Appendices on PQ Mitigation Devices Used in Report (ADDED - Including Sizing Details)	☐
E25	User defined ordering areas and equipment Investigator (will carry over to reports)	☐
E26	For Categorized Data, Curves Module, Parse Type I, Type II, and Type III PQ Data Sets for Plotting and Use	☐
E27	Enable Benchmark Studies in PQ Data Section of Report	☐
E28	Enable Base-Line PQ Data Plot for Report Purposes	☐
E29	Add solutions roll-up matrix to Investigator and Reporting	☐
E30	Implement PQ View Data Connections (pending outcome of item I1)	☐

*** 2021 PQI UG Prioritization Survey ***

Part 3: Pick Which Features We Investigate Next for Future Revisions (3.7+)

Item	New Feature	Investigate First (Check up to 10)
I1	Functional Specification for PQView Data Set Connections	Spring 2021
I2	PQ Data Transformation Tool, calculate low side data after transformation, Utilize existing code/models, Type 1, 2, 3,	☐
I3	Improve PQ mitigator installation cost calculation granularity based on mitigator chosen – could be done during specification stage.	☐
I4	Mitigation statistics for nominal year (user-selectable)	☐
I5	User Granularity Improvement /Roll Based Access	☐
I6	Link to drive setting manuals (online/downloaded onto PQI)	☐
I7	PQDiff data Import (Using GPA's OpenXDA engine)	☐
I8	Add "Option 2" capability for Mitigators	☐
I9	Home Page Revamp (In progress links, quick links, user-defined customization), Linked to Granularity Improvement	☐
I10	revamp/rework reporting engine - allow for other outputs such as PDF or power point	☐
I11	Utility Solutions - add way to prioritize and qualify transmission and distribution mitigation projects	☐
I12	Allow Branding Input	☐
I13	Use phrasing "sags below a percentage"	☐
I14	Add Granularity to costs shown in report	☐
I15	Provide a way for members to submit curves for EPRI database	☐
I16	Add user-defined section in the report	☐

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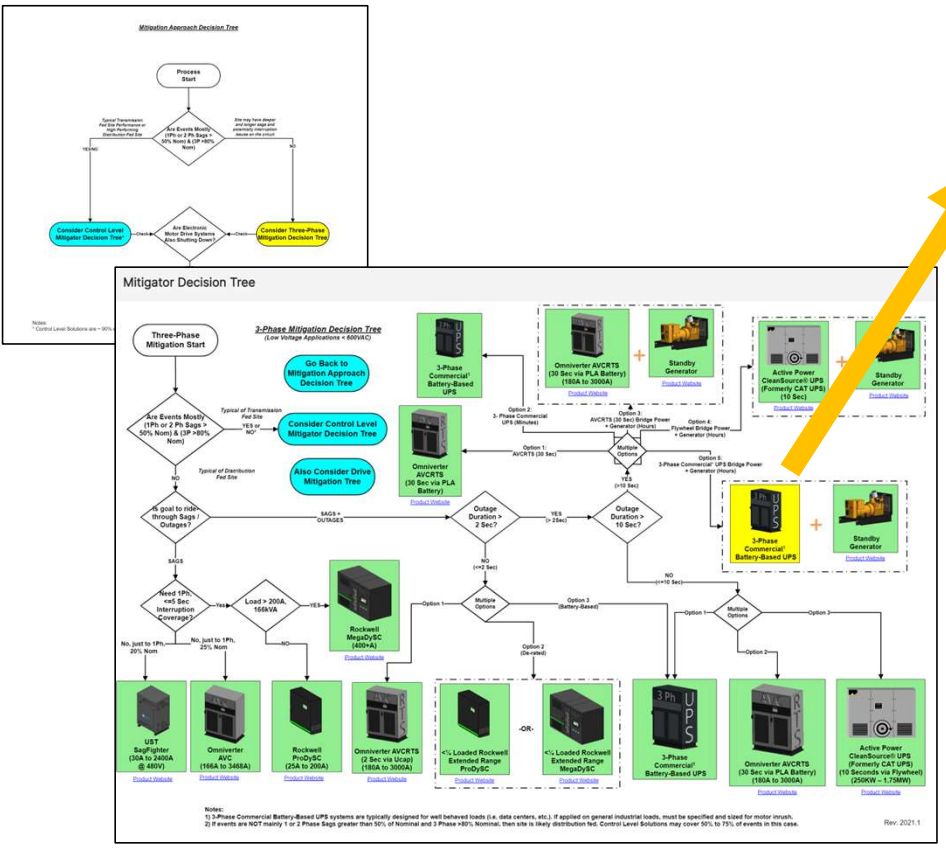
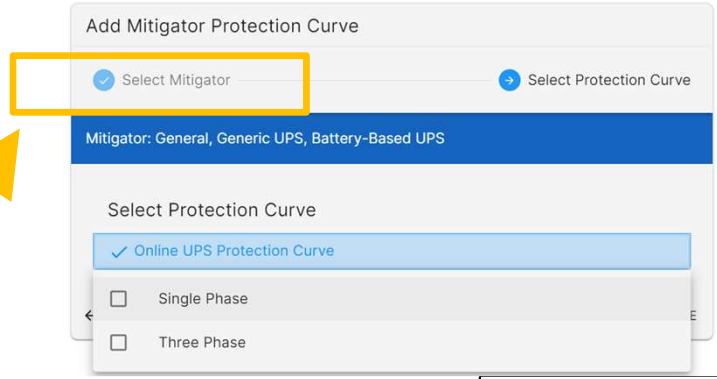
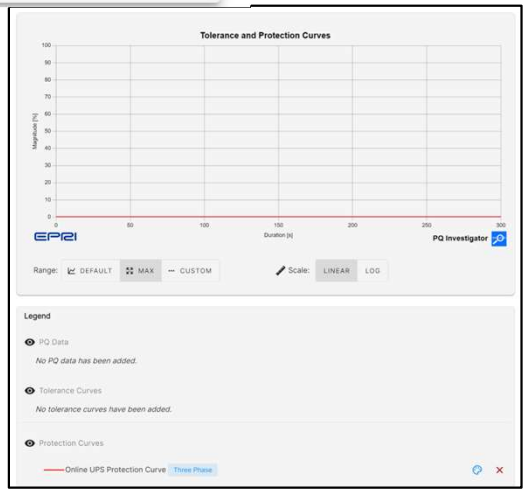
… Of new features …



1. Select a Mitigator from the Decision Tree





2. Protection Curves Automatically Populate Based on Selection

Use Mitigator Decision Trees to Automatically Populate Dropdown Menus

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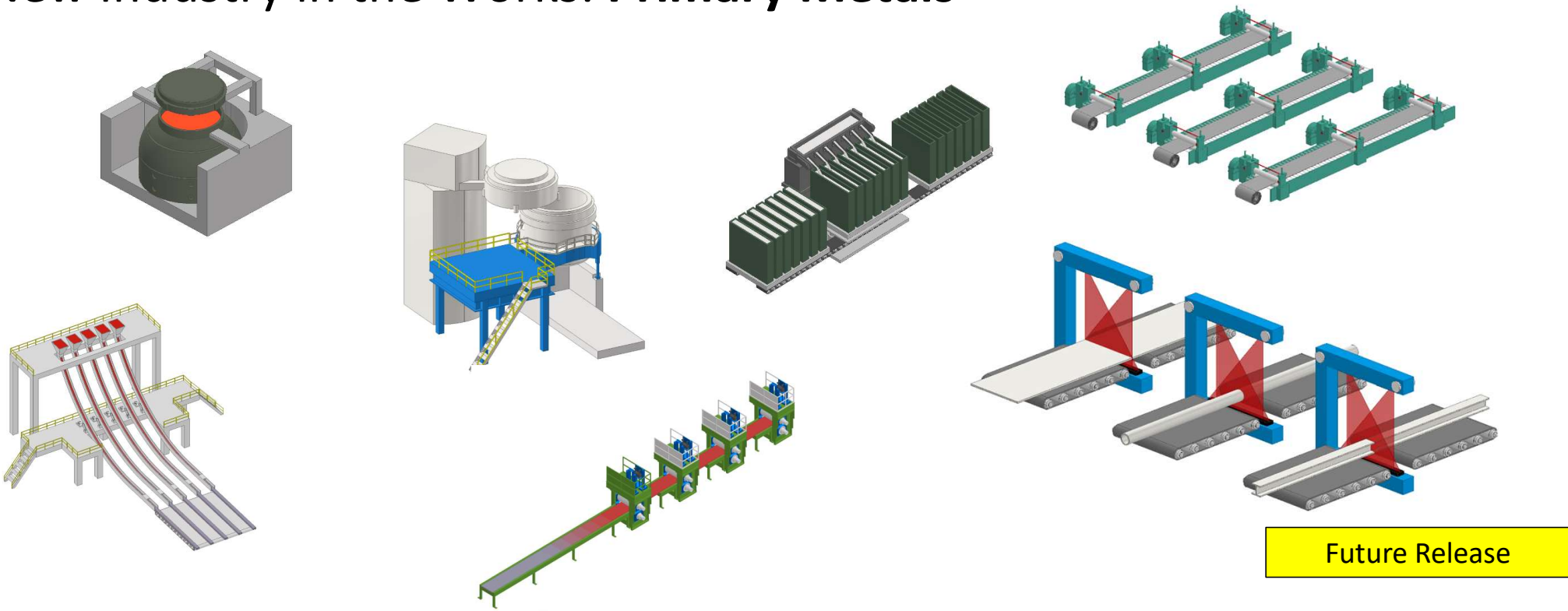
… And content continually added…

New Industry in the Works: **Primary Metals**



Future Release

New Data Continually Added to Navigator Module

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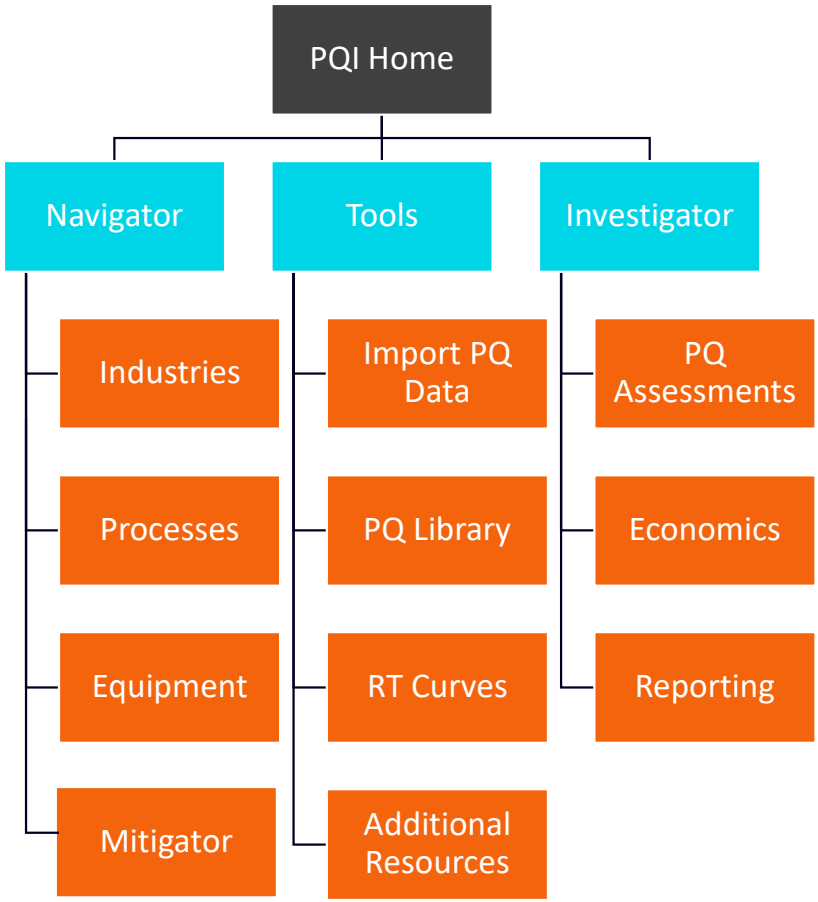
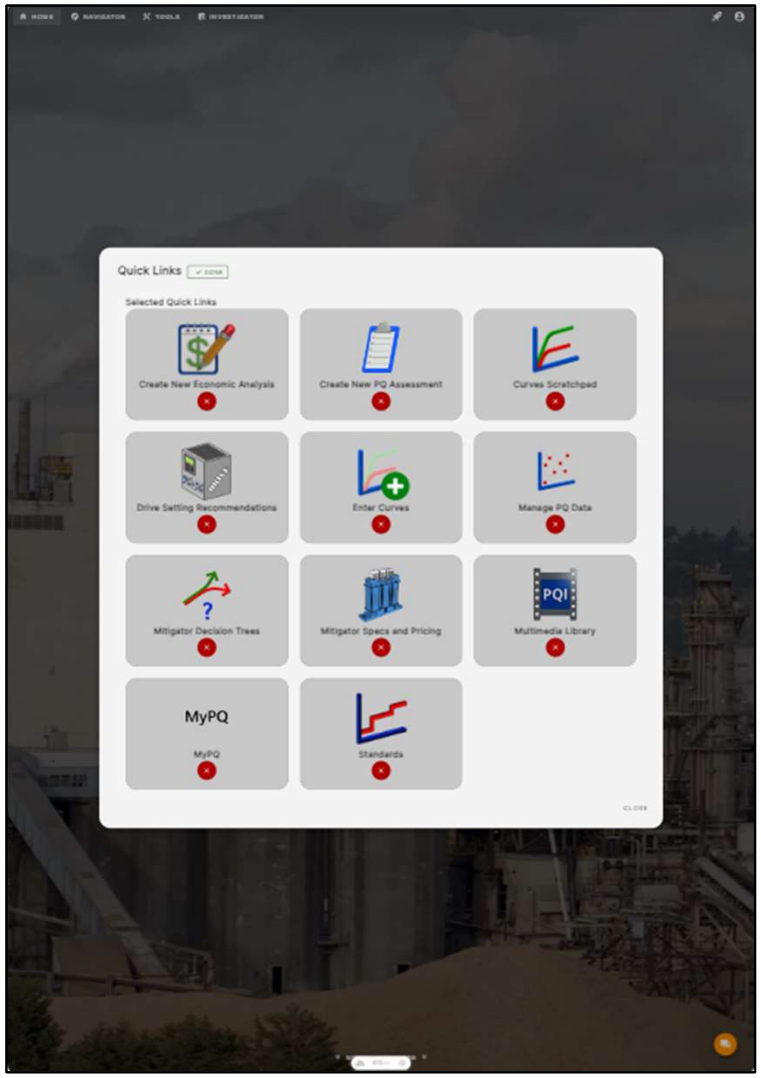
PQI Site Structure





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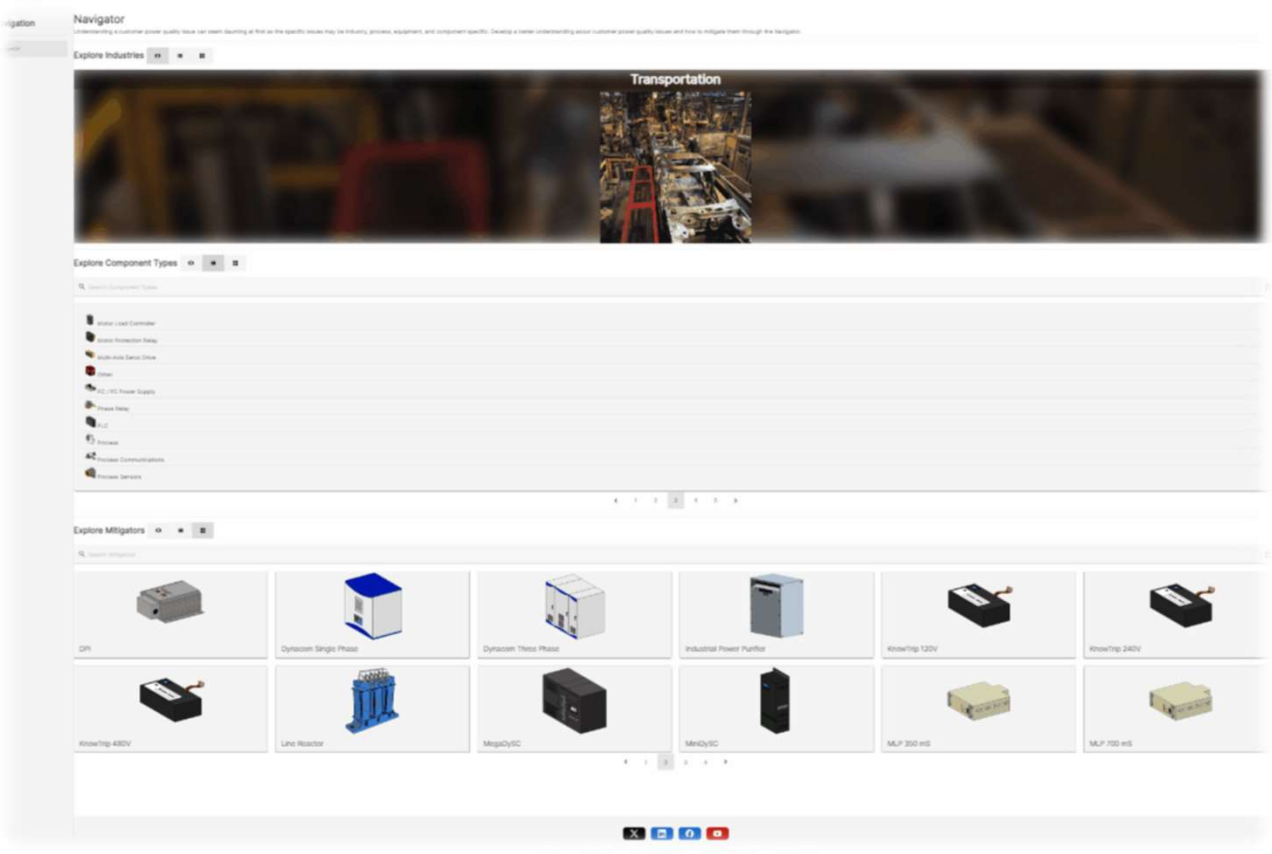
PQI Structure – Navigator Module

- Learn about a wide variety of industries, processes, equipment, and assemblies
- View information on commonly-used industrial components, including tolerance curves and harmonics charts
- Learn about mitigation strategies for PQ events



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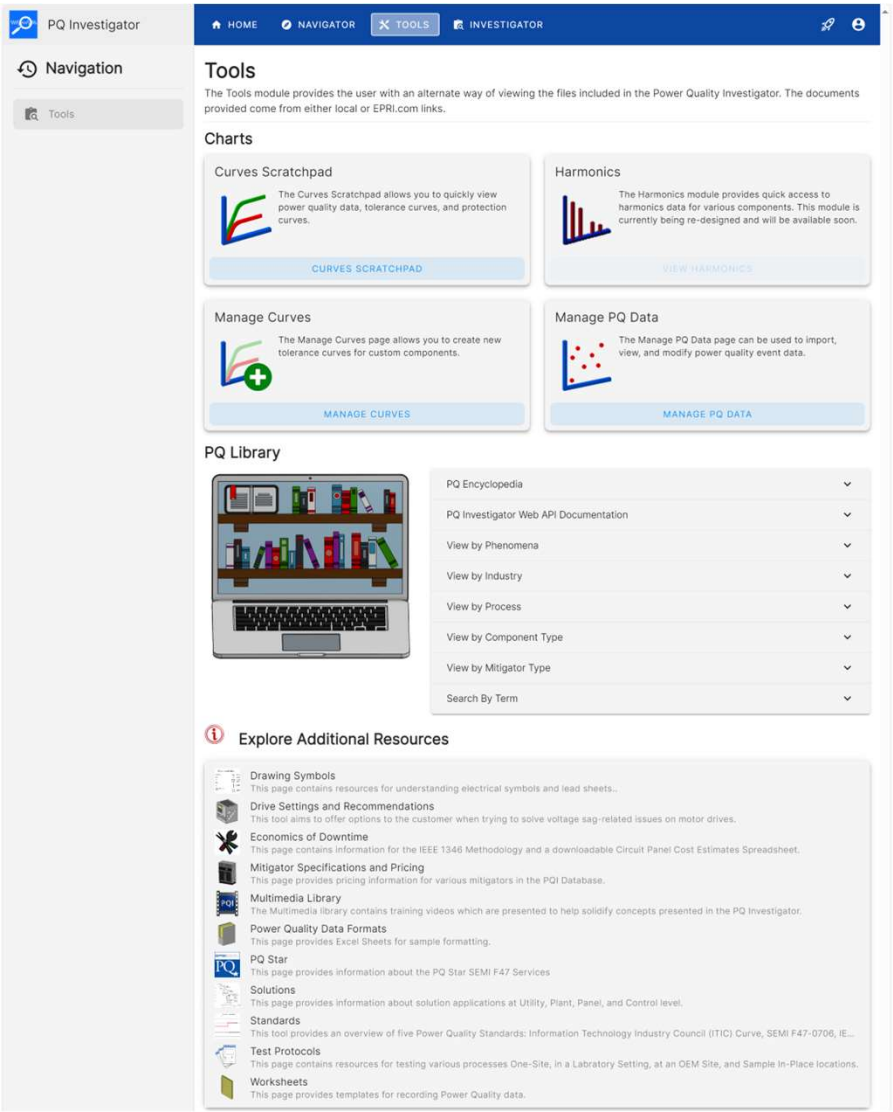
PQI Structure – Tools Module

- Use a scratchpad to view tolerance and mitigator curves, along with imported PQ event data
- View Harmonics charts for various components (Pending)
- Enter custom curves for components
- Import and view PQ event data
- Browse the EPRI PQ Library
- Multi-Media Library
- Drive Settings/Recommendations
- Mitigator Specs and Pricing
- Training Material
- Standards
- And Much More!



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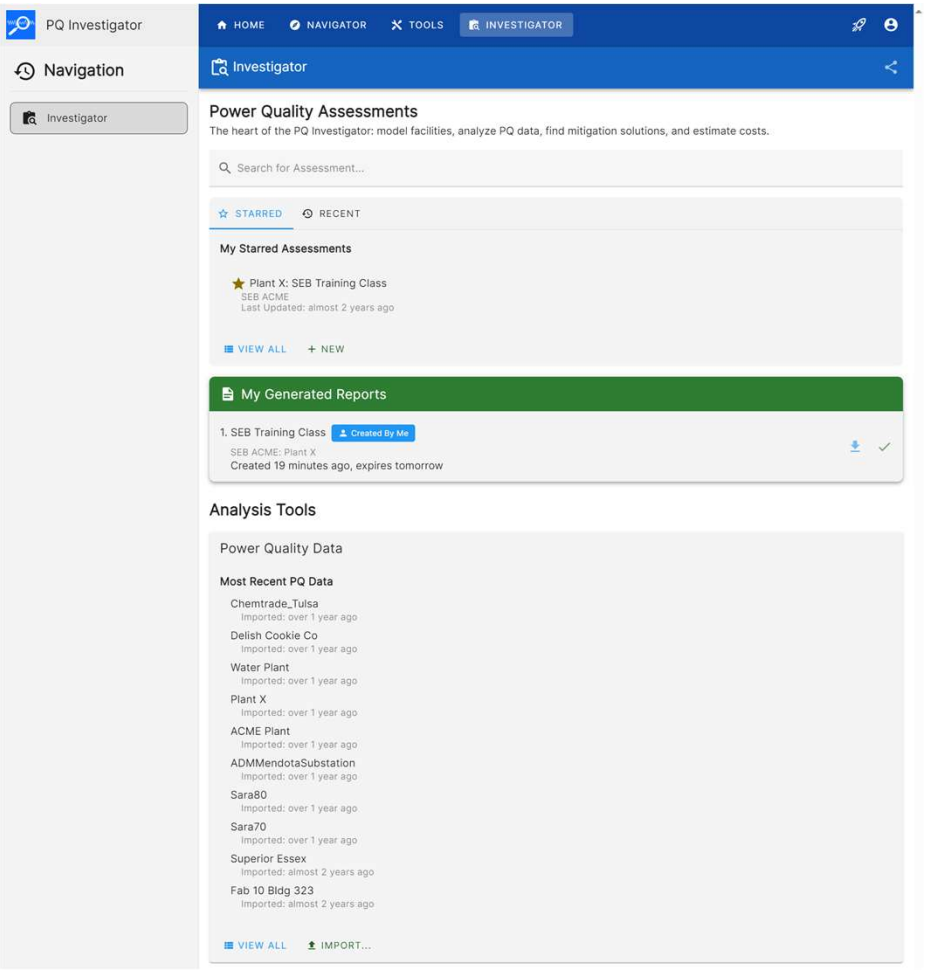
PQI Structure – Investigator Module

- The Investigator Module allows you to:
  - Create PQ Assessment reports
    - Consists of defined Areas, Equipment, and Components
  - Research and recommend solutions to mitigate susceptible components
  - Determine economics of solution implementation
  - Estimate downtime costs
  - Generate a report to send to the customer



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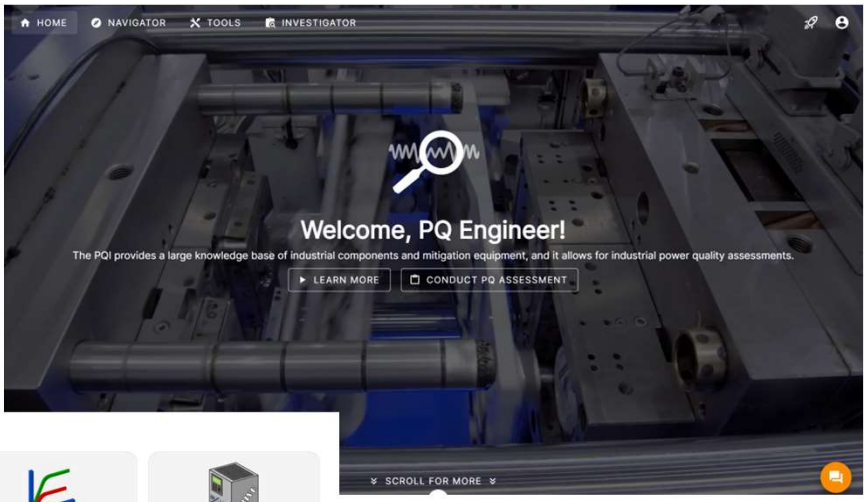
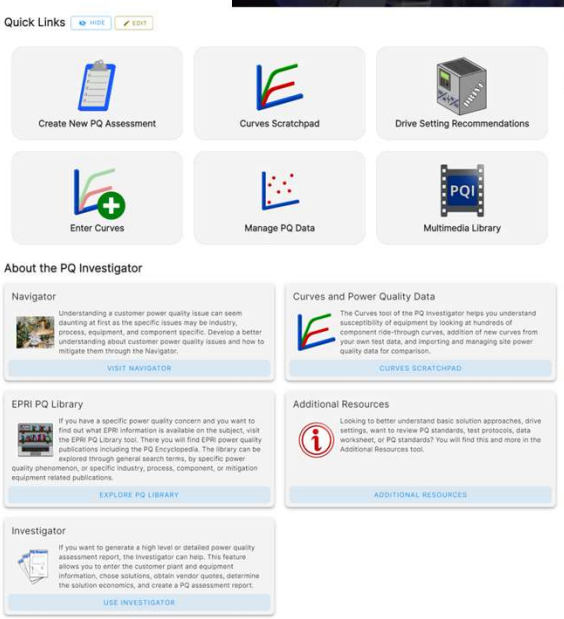
Home Screen Welcome Content…

- Provides a way to quickly jump into functionality at key locations:
  - Learn More
  - Jump to PQ Assessments
  - Via Quick Links (default)
  - Via About PQI Descriptive Links





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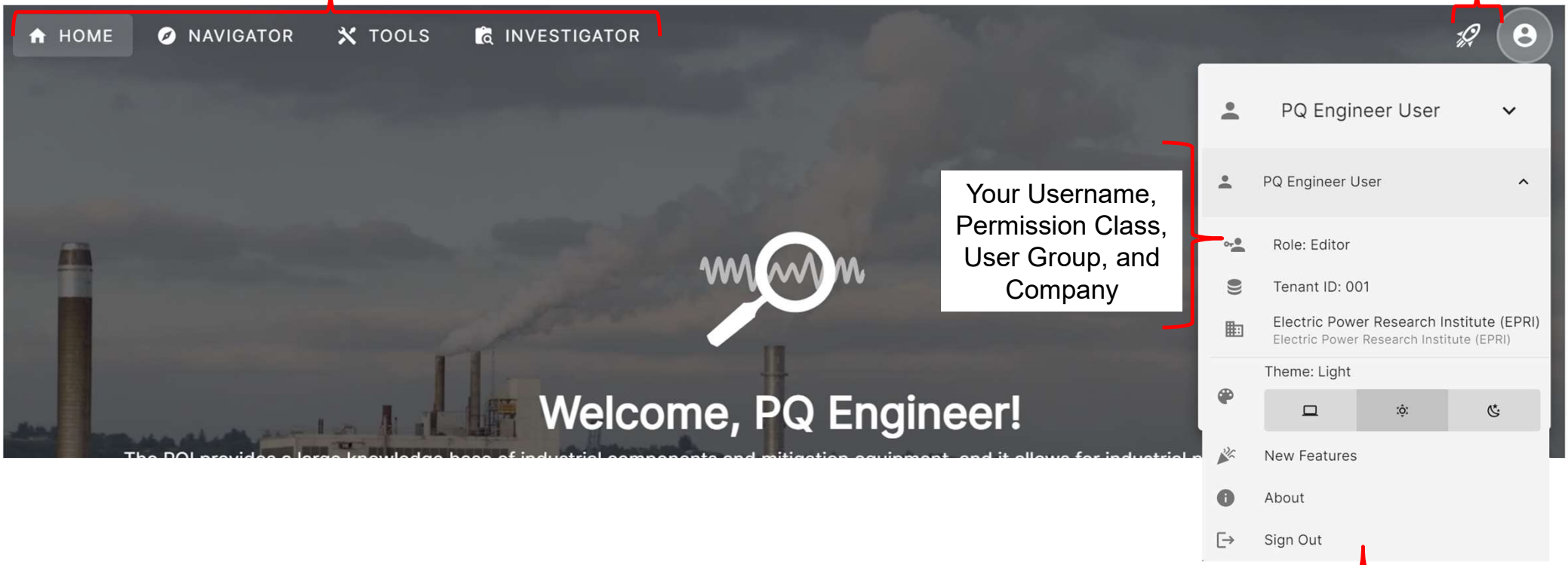
Understanding the Menu Bar (Parent Page View)

Selection of Home, Navigator Module, Tools Module, Investigator Module or Help

View and Customize Quick Links



Your Username, Permission Class, User Group, and Company

Ability to toggle between Light/Dark Mode, see a quick list of features unique to the current release, visit the legal permissions and third party softwares associated with the PQ Investigator, and ability to sign out of your PQ account

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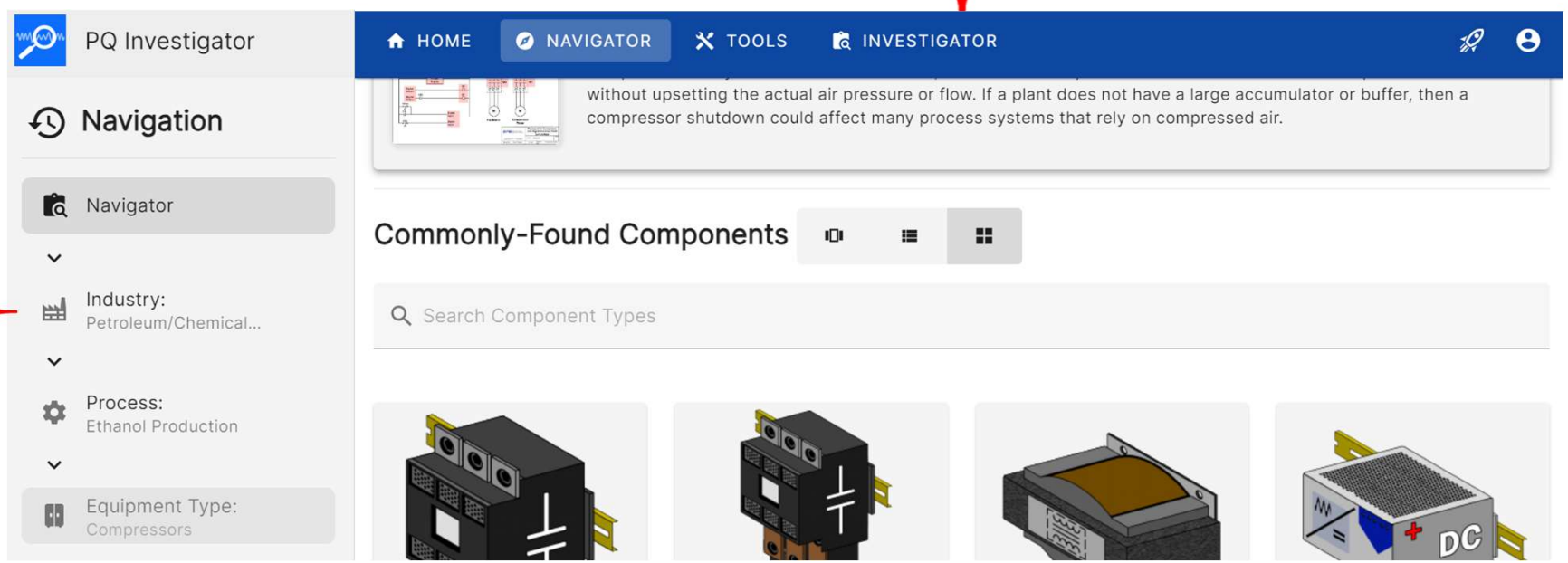
Understanding the Menu Bar (Child Page View)

Parent View will still be visible on wide screens but may not be visible on Cell Phones/Tablets. Navigational Menu Bar items disappear on screen widths of 1199 Pixels or smaller, but the Quick Link Rocket and Account icons remain.

GPS through the site. Can be used to backtrack and/or remember where you are in relation to parent pages



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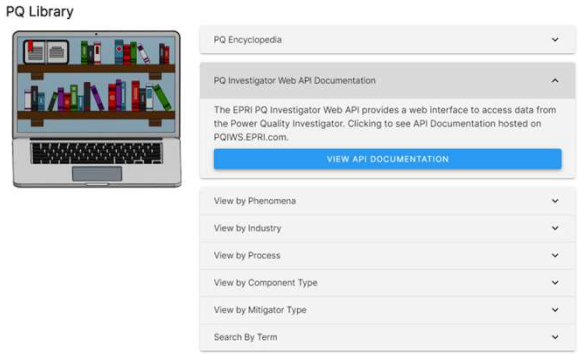
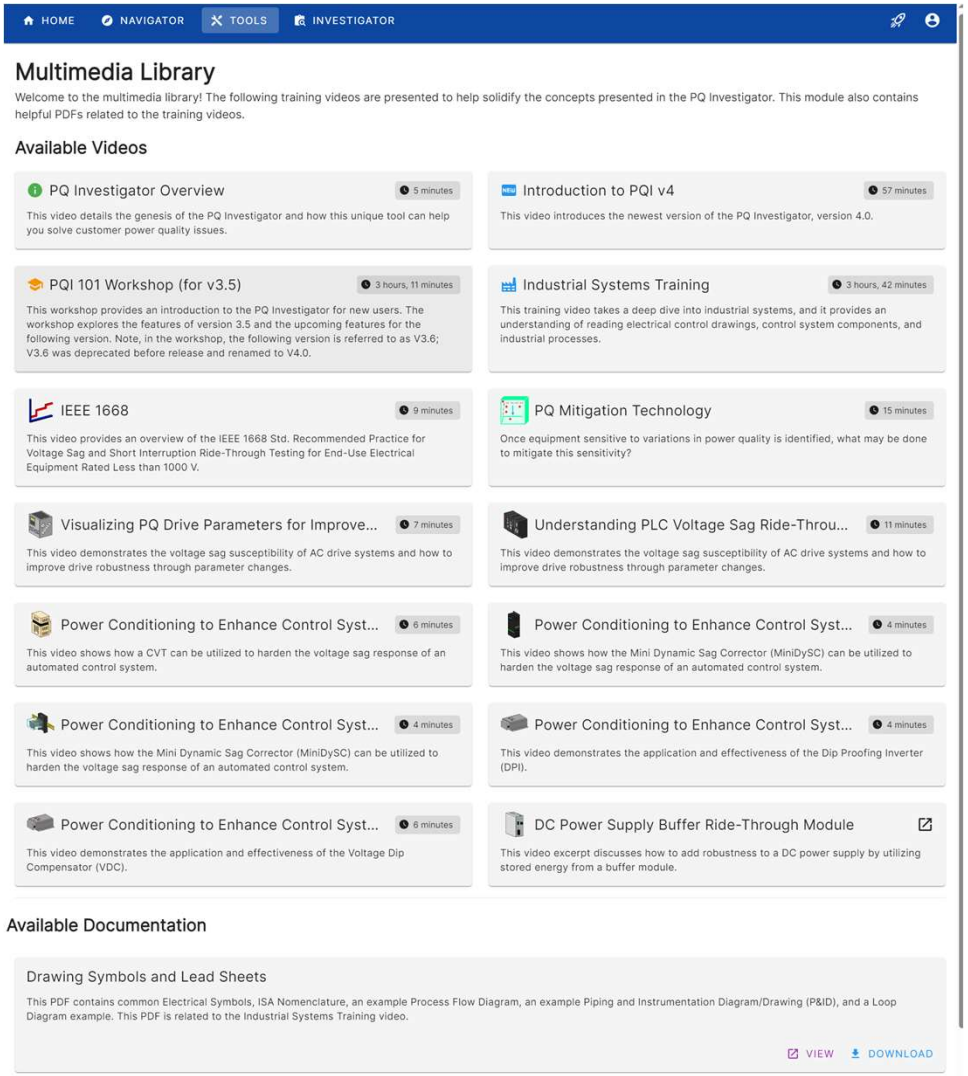
Main Help Page

- To view PQ Investigator guides, go to Tools and look in the Multimedia Library.
  - Among other helpful videos, you will find two overviews and a Workshop for the PQI.
- For Developers, the PQ Investigator Web API Documentation can be found in the PQ Library module on the Tools page.





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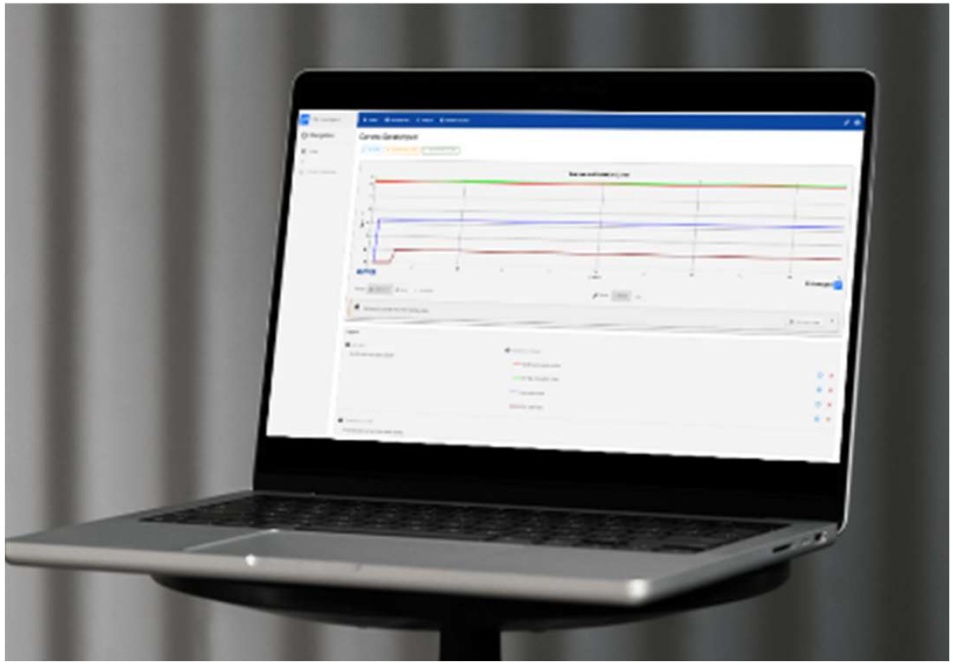
PQI Members: Connect to PQI Via the Web

- First, Connect your computer to the Internet
  - See EPRI Visitor Credentials
- Go to your browser and type:
  - https://pqi.epri.com
- Log in via your EPRI Username and Password Credentials
- No Need to Install any Software on your Computer or Server



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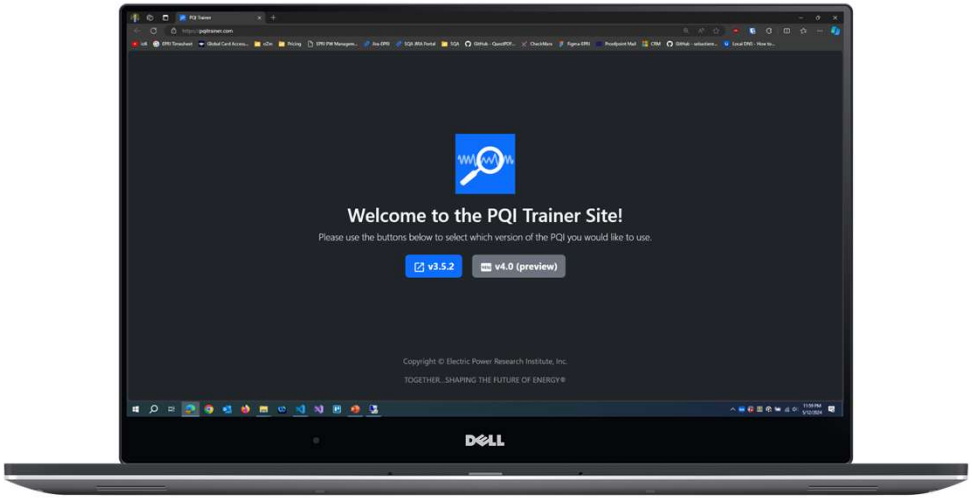
Non PQI Members: Connect to PQI Via the Portable Trainer Box

- Open web browser
- Find Wi-Fi network called “PQI-2”
- WiFi password: “training”
- Go to your browser and type:
  - https://pqitrainer.com
- No need to install any software on your computer
- Note: you will not have internet access



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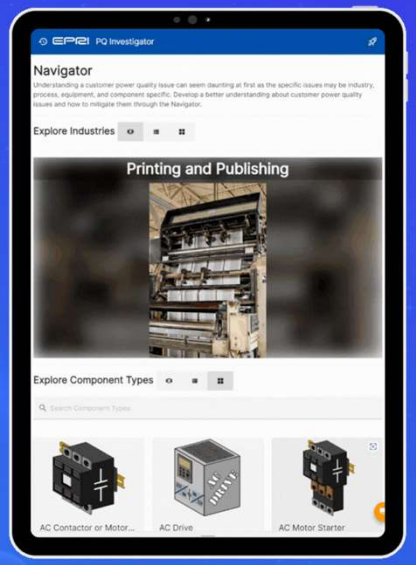
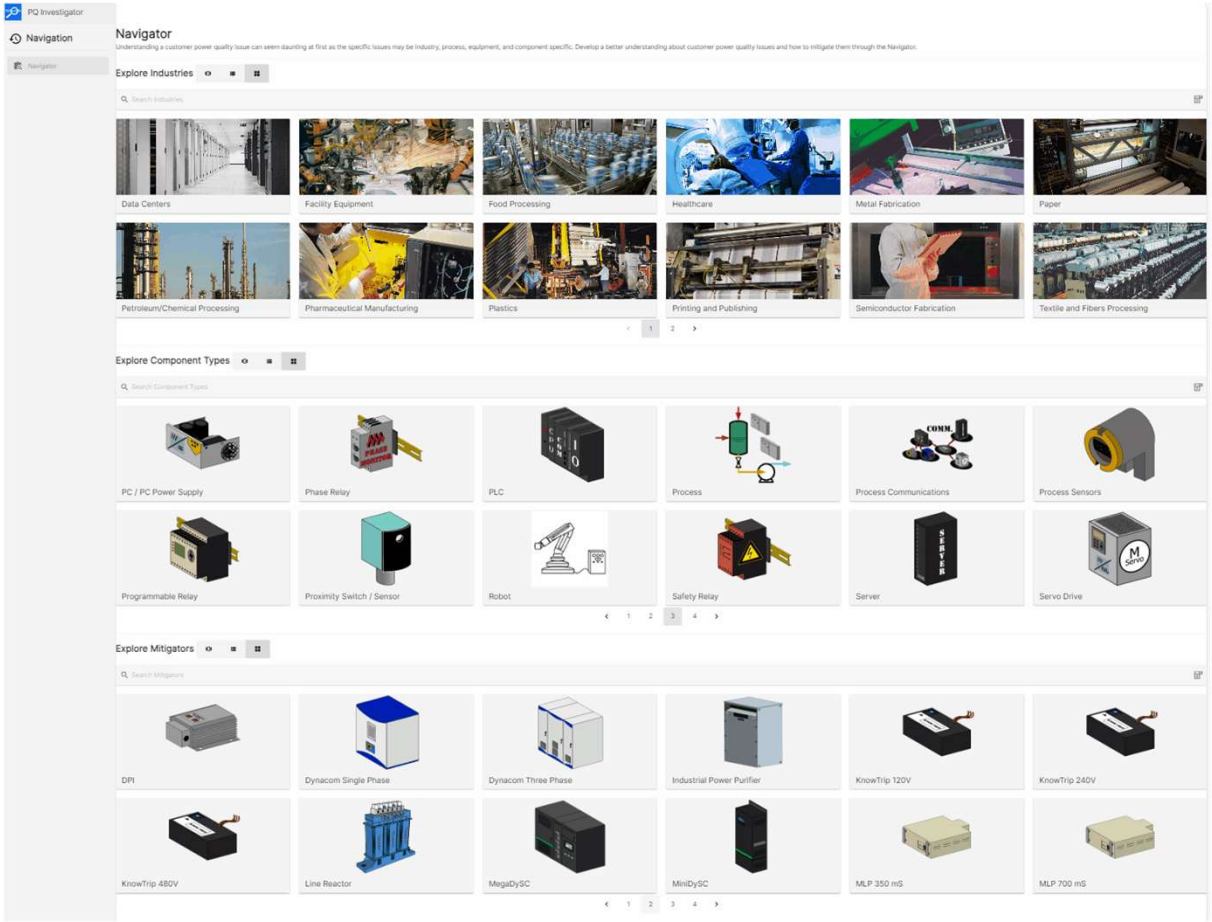
Navigator Module



Natural "Drill Down" Under Navigator…

- Select An Industry
  - View related EPRI Pubs List
  - View related trade organization sites
  - Find a Process under that Industry
    - Find a related EPRI documents
    - View an equipment type under that process
      - View a related EPRI documents
      - View a component within an equipment type
        - Select a related publication
        - View a tolerance curve for the component

- New Feature: Equipment and Components are shown at each stage, but become more specific as the user drills down



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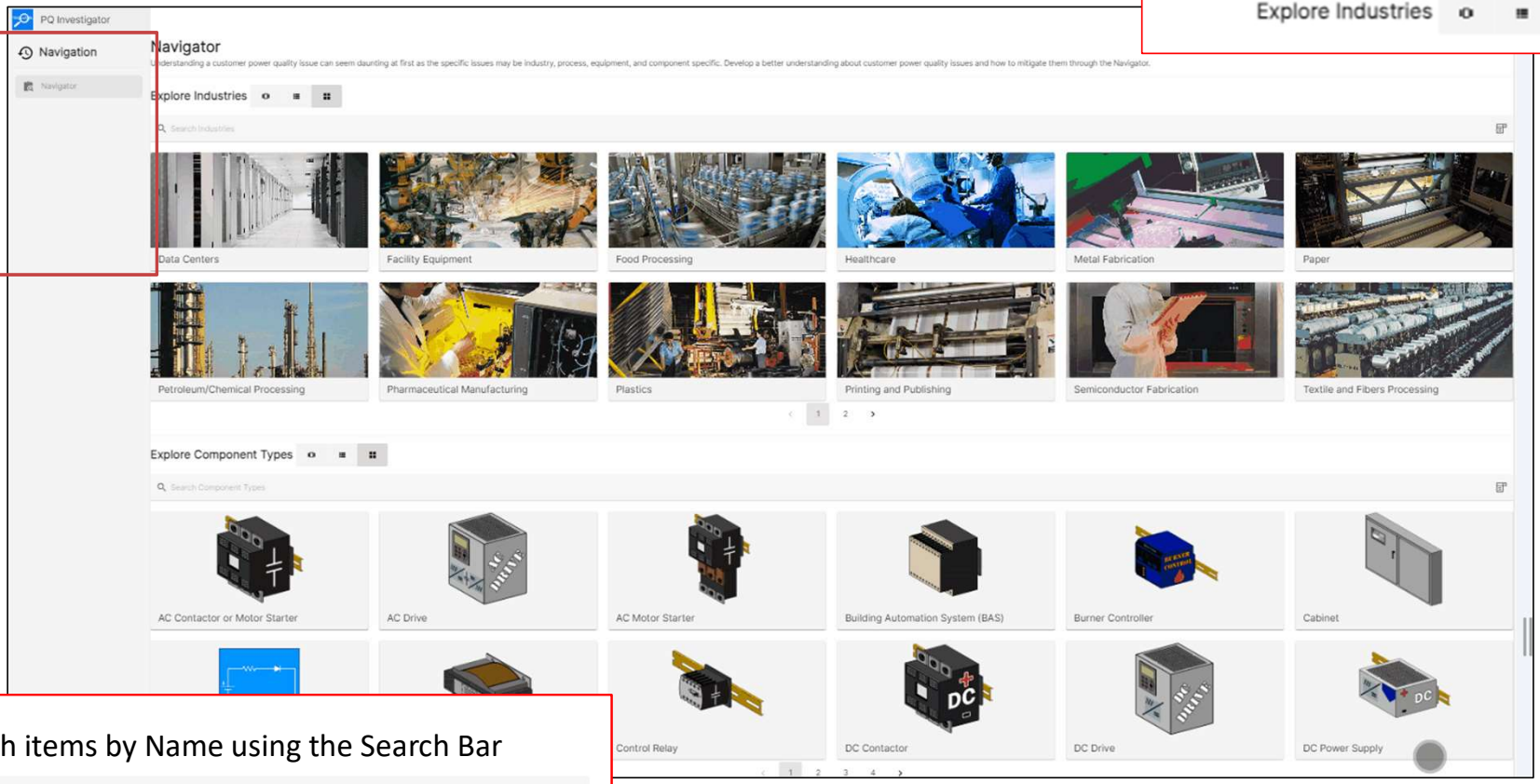
Navigator Page Overview

Choose between three display modes: Carousel, List, Grid

Explore Industries

Visual map as the user drills down



Search items by Name using the Search Bar

Search Industries

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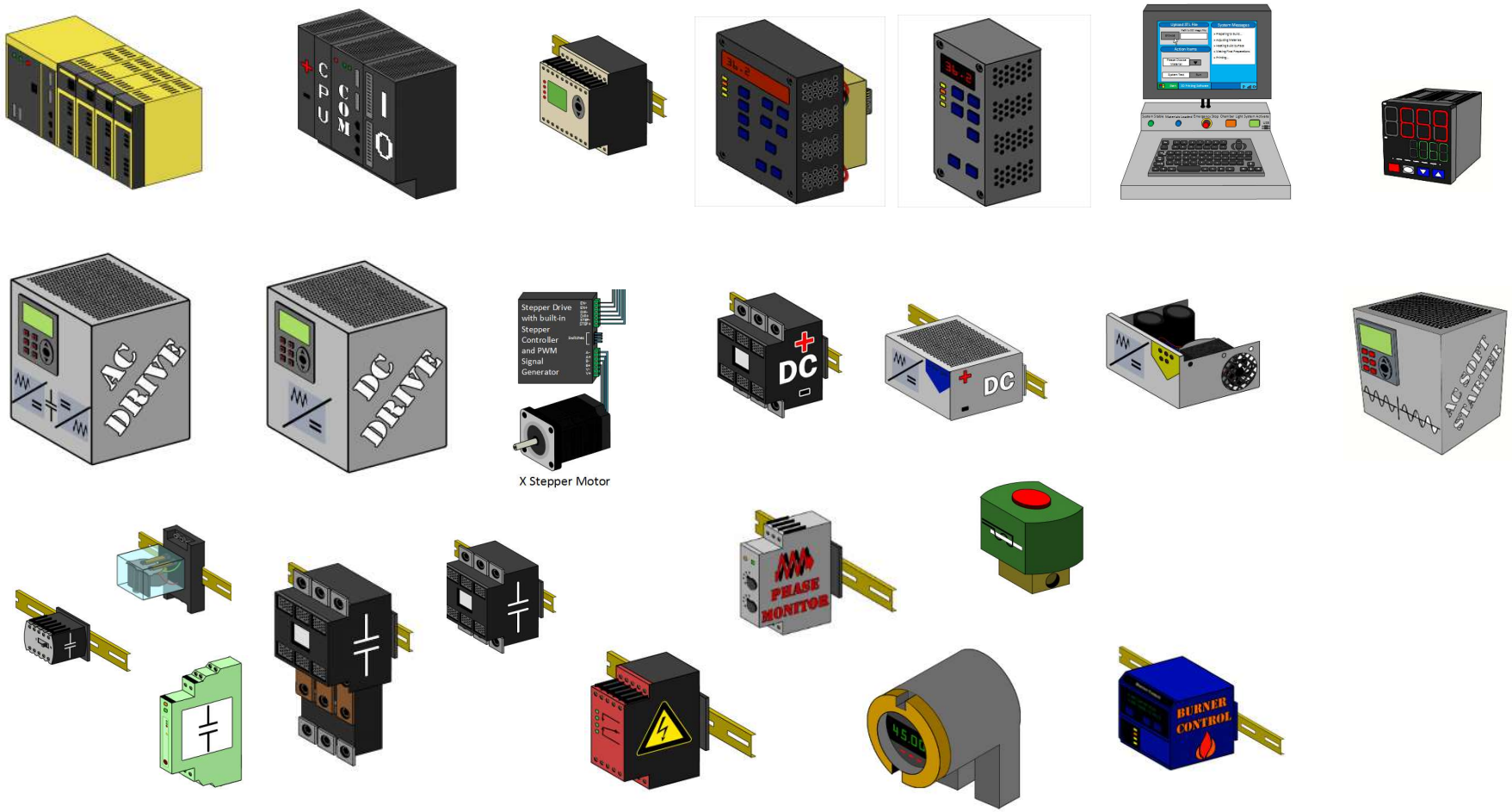
Components Make up “Equipment”



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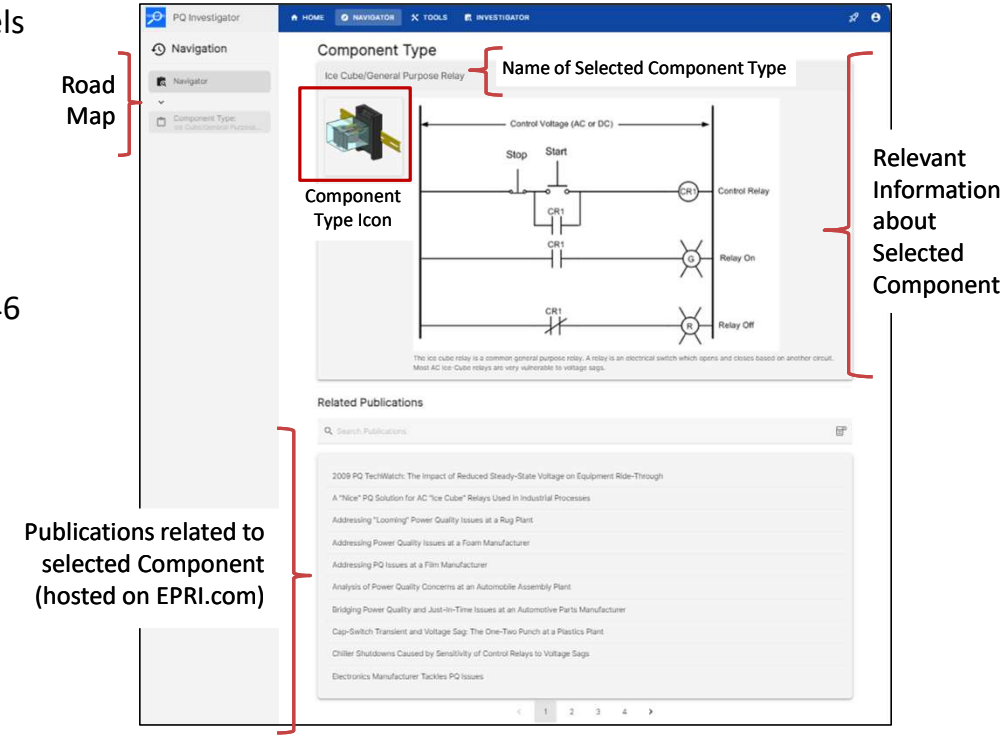
Component Types

- "Equipment" is made up of "Components"
- 45 Separate Component Type Categories
  - Most all components have ride-through curves from various models
- Important Notes:
  - Standards
    - Includes Ride-Through Requirement Curves for IEC 61000-4-11/34, SEMI F-47, ITIC, IEEE 1668, NERC Standard PRC-024-2
  - If you cannot find the specific component that you want, IEEE 1346 typical curves may still be applicable
  - Most component types have at least one or more associated component ride-through curves
    - Some are for place holders that are used in the Investigator Module (i.e. cabinet, machine robot, etc.)



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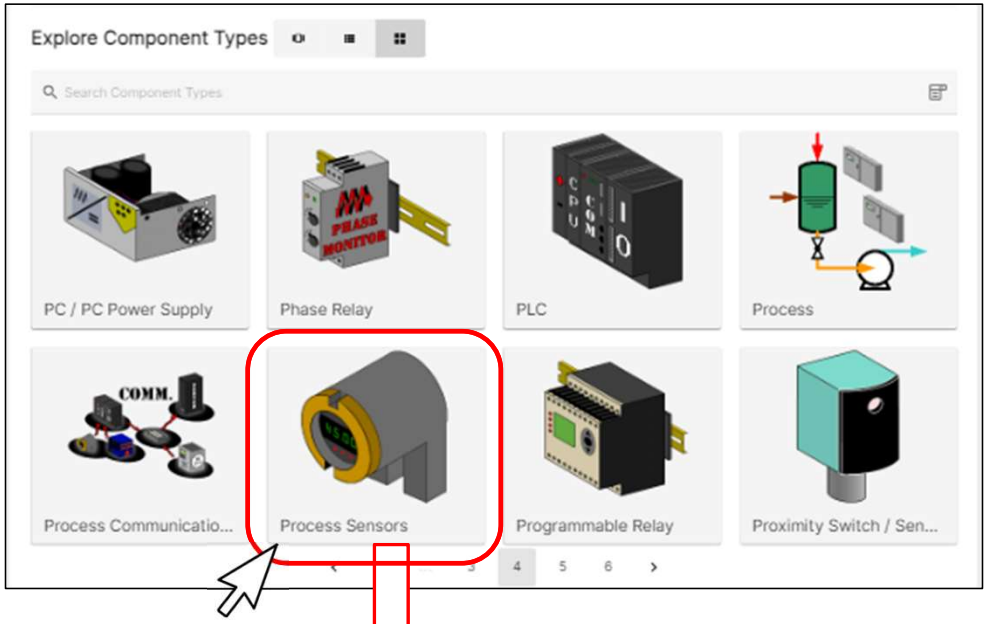
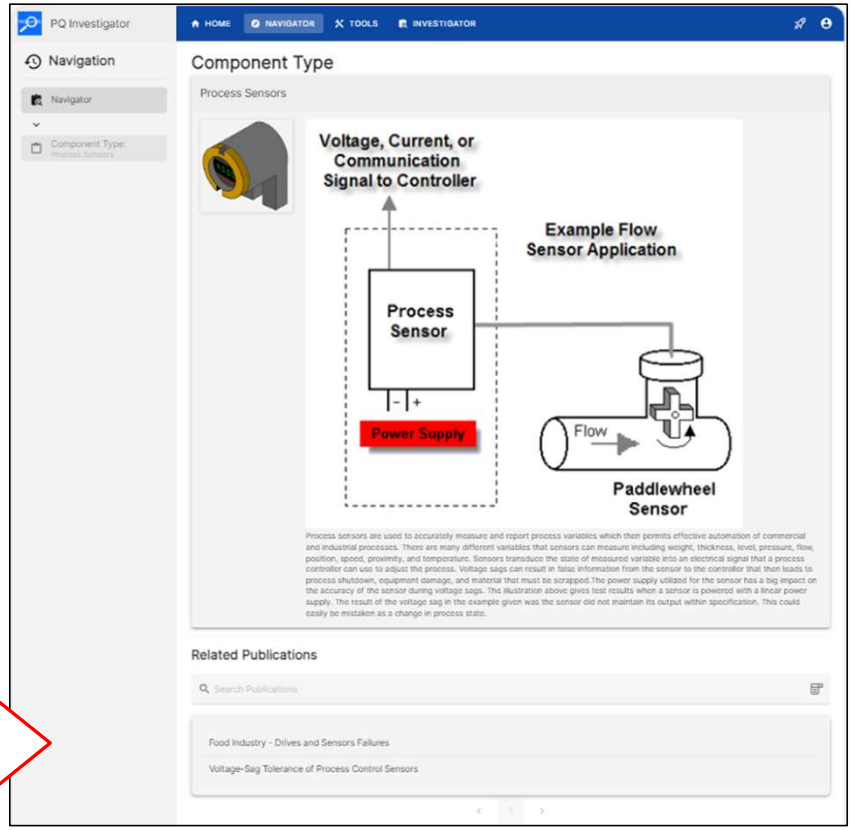
Component Area of Navigator Page

- Select Component Type to go to Component Type Page





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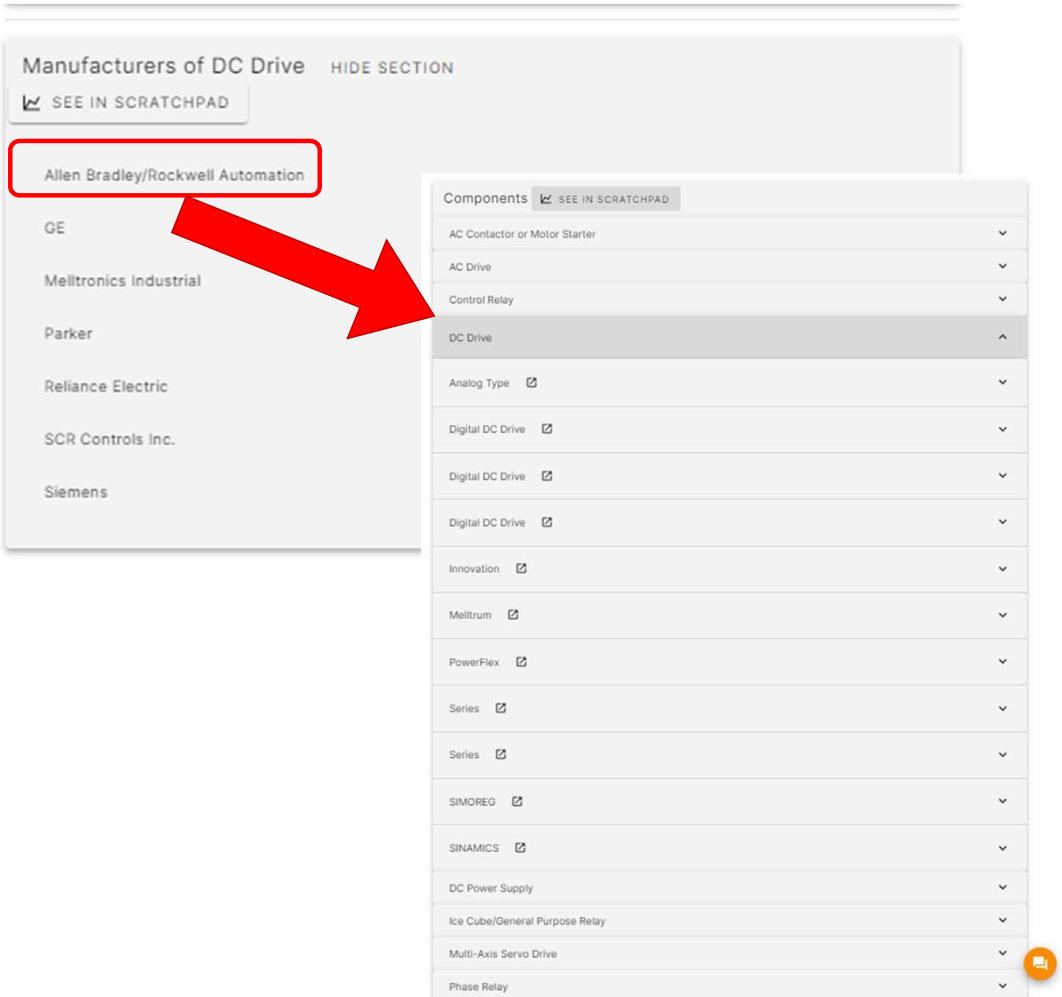
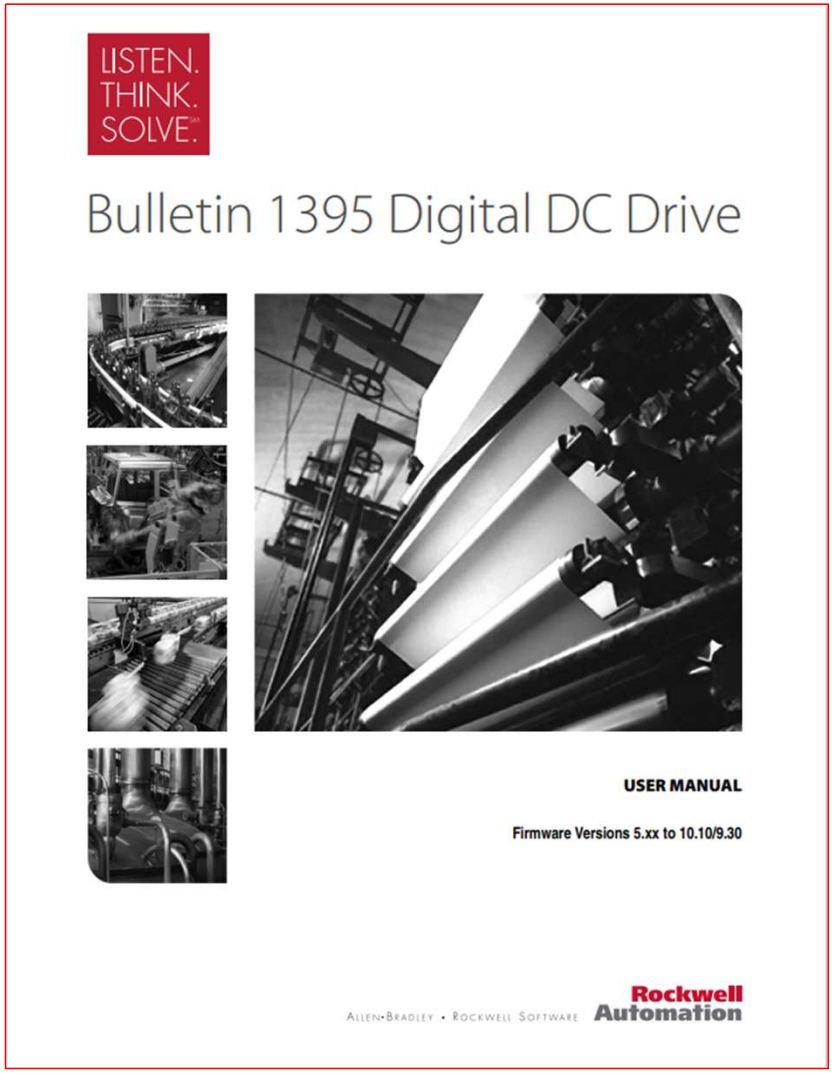
Component Area of Navigator Page





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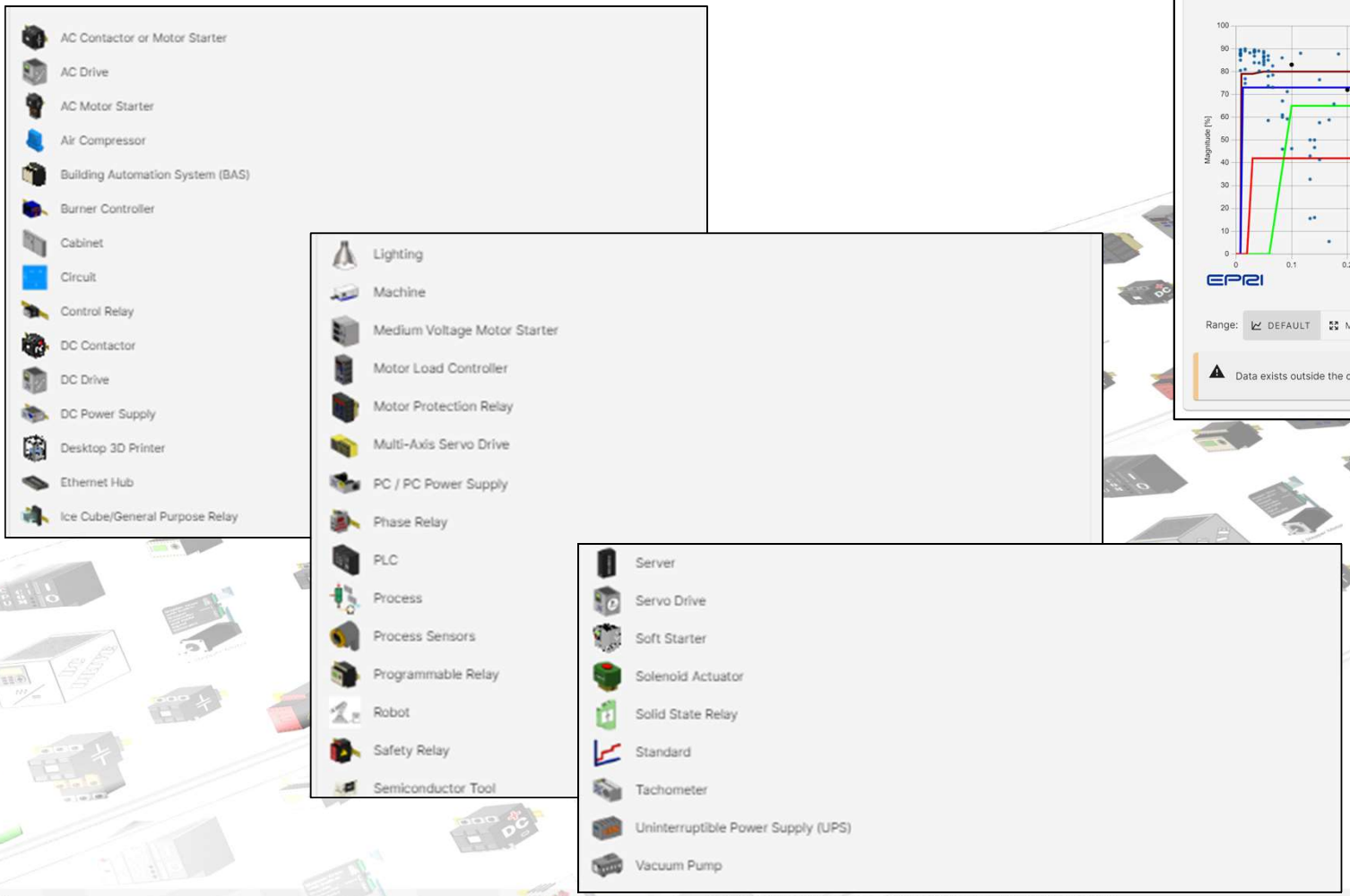
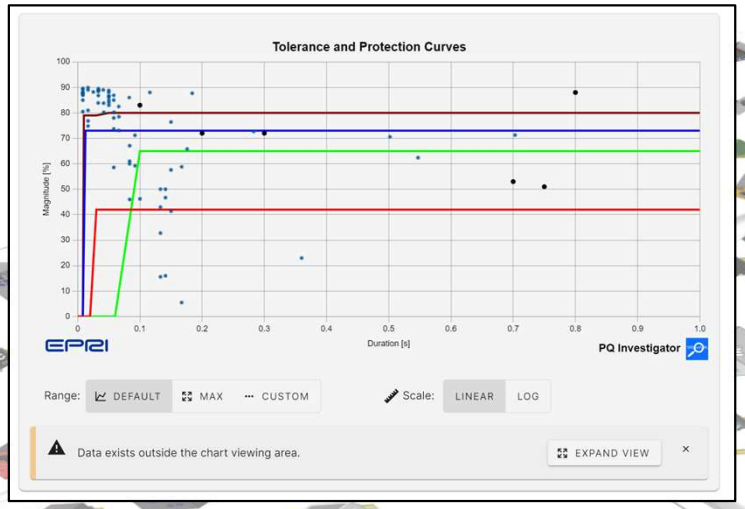
MM0

Over 1,400 Voltage Sag Ride-Through Curves in the Database





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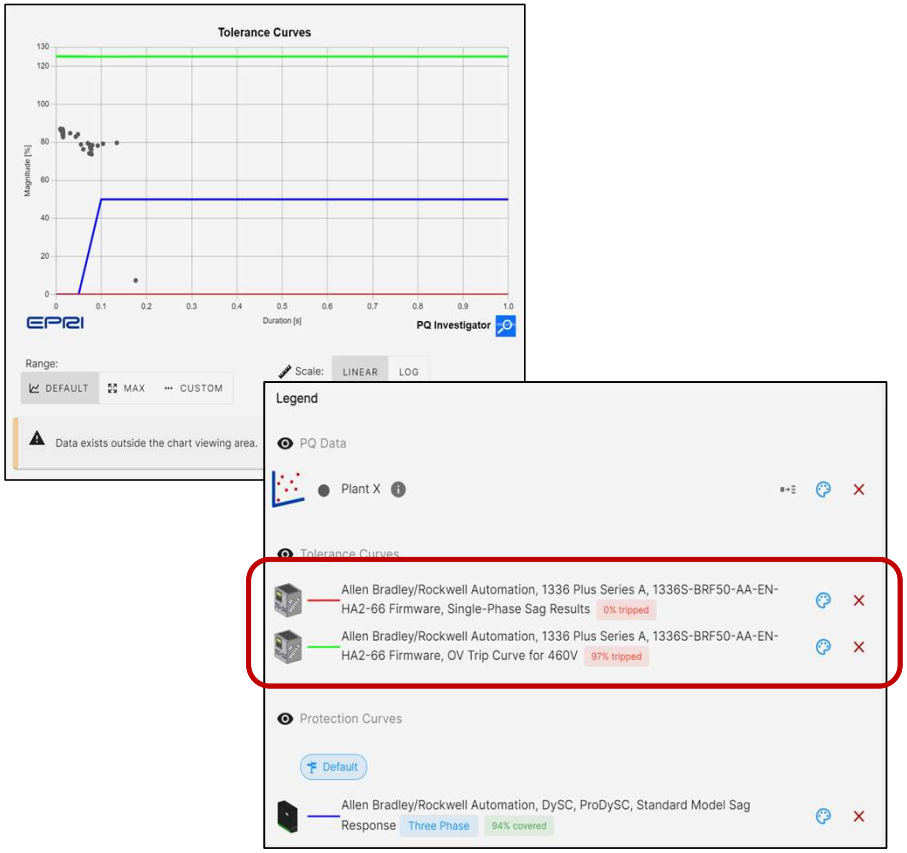
Slide 52

MM0 Changes made: "780" to "1400". Will double check with Eric. Number taken by select * from in SQL of Common.ToleranceCurve

Mckinney, Makayla, 2024-07-24T12:02:43.659

160 Over-Voltage Trip Curves for 160 Drives



OV Trip Curve for an AC Drive on the PQI

We have Researched Drive Manuals for OV Trip Levels

Manufacturer	Series/Model	Voltage	Trip Lev	OV Trip Leve
ABB	ACH400	380	661	1.23
ABB	ACH400	440	765	1.23
ABB	ACH550	240		1.30
ABB	ACH550	480		1.30
ABB	ACH550	600		1.30
Allen Bradley	1336 Plus	230	405	1.25
Allen Bradley	1336 Plus	460	810	1.25
Allen Bradley	1336 Plus	550	1013	1.30
Allen Bradley	Bulletin 160	220	400	1.29
Allen Bradley	Bulletin 160	420	800	1.35
Allen Bradley	Bulletin 1557			1.20
Allen Bradley	Bulletin 1333	220	430	1.38
Allen Bradley	Bulletin 1333	420	820	1.38
Allen Bradley	PowerFlex 70	240	405	1.19
Allen Bradley	PowerFlex 70	480	810	1.19
Allen Bradley	PowerFlex 70	600	1013	1.19
Allen Bradley	Powerflex 523	240	405	1.19
Allen Bradley	Powerflex 523	480	810	1.19
Allen Bradley	Powerflex 523	575	1050	1.29
Allen Bradley	Powerflex 525	240	405	1.19
Allen Bradley	Powerflex 525	480	810	1.19
Allen Bradley	Powerflex 525	575	1050	1.29
Allen Bradley	Powerflex 700H	500	911	1.29

OV Trip Curves have been added for many different brands, including Danfoss, Schneider Electric, Yaskawa, and more!

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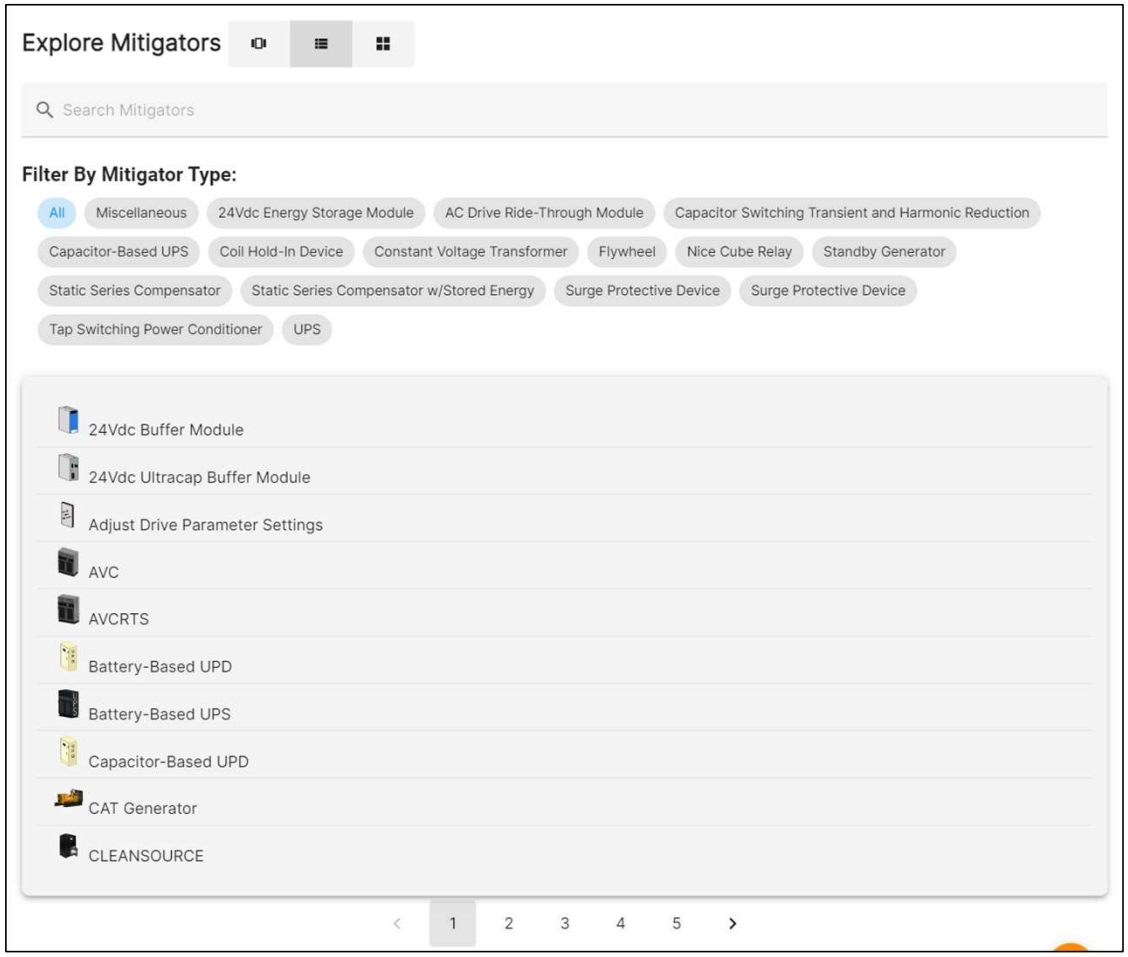
Mitigator Area of Navigator Page: Now by Mitigator!



"Meatballs on Top!"

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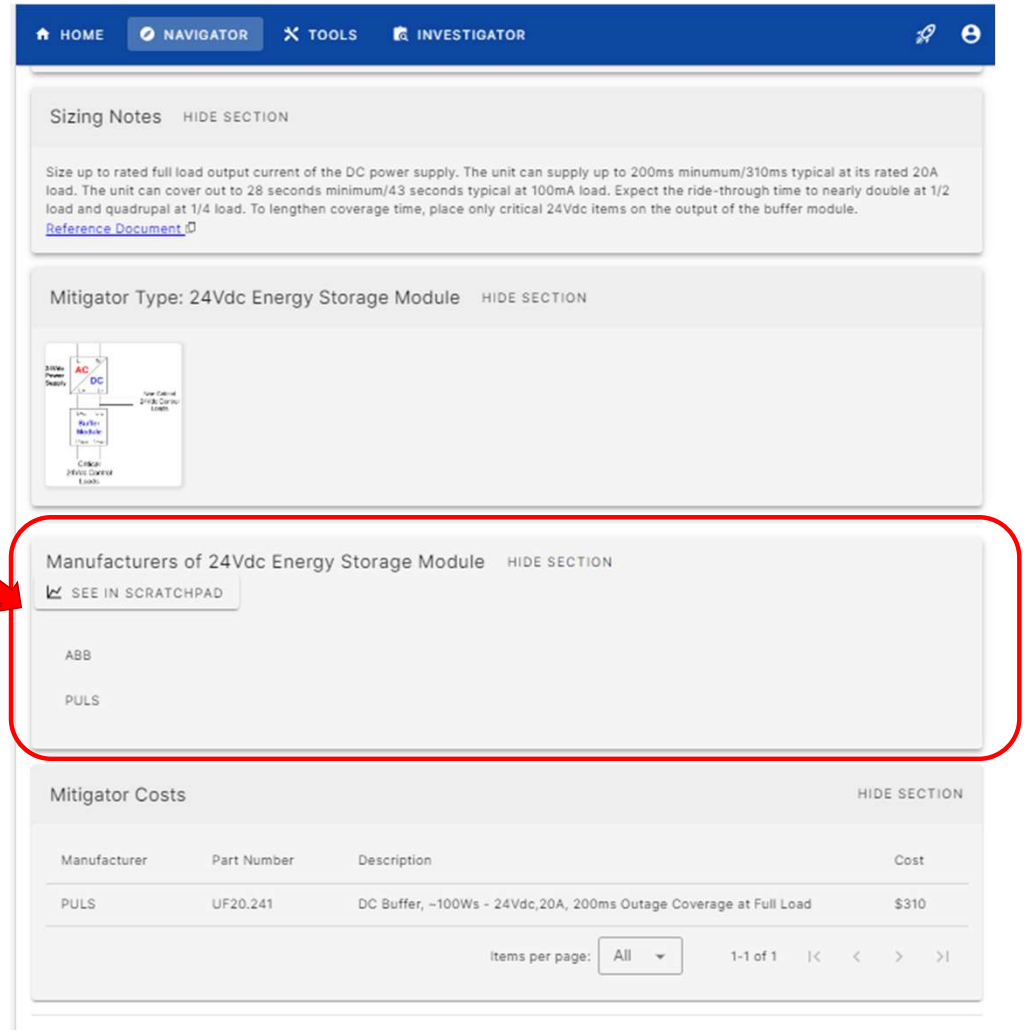
Mitigator Area of Navigator Page

See Manufacturers of Mitigator Type on the Mitigator Page



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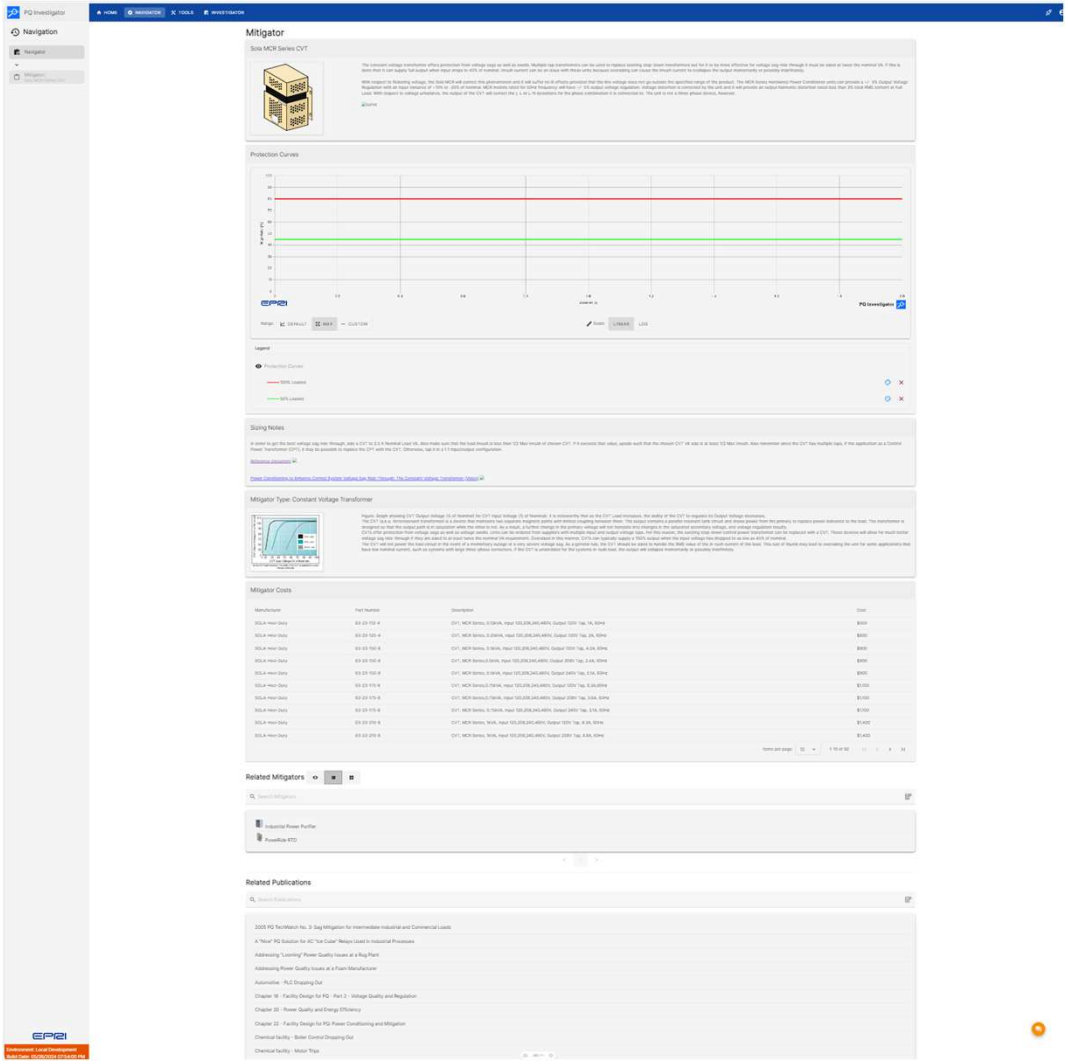
Mitigator Details Overview

- The Mitigator details screen contains:
  - Description of Selected Mitigator
  - Typical Protection Curves
  - Sizing Notes (When Applicable)
  - Description of Mitigator Type that selected Mitigator belongs to
  - Associated Costs
  - Related Mitigators by Mitigator Type
  - Publications related to selected Mitigator



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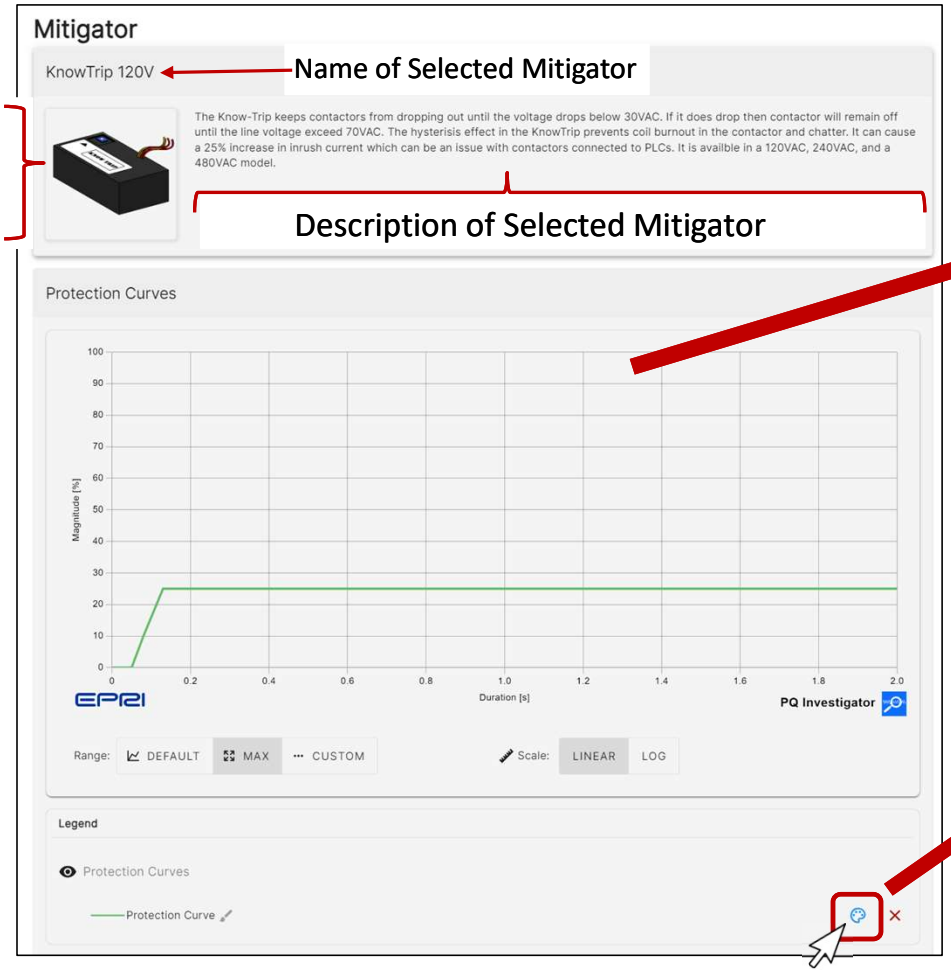
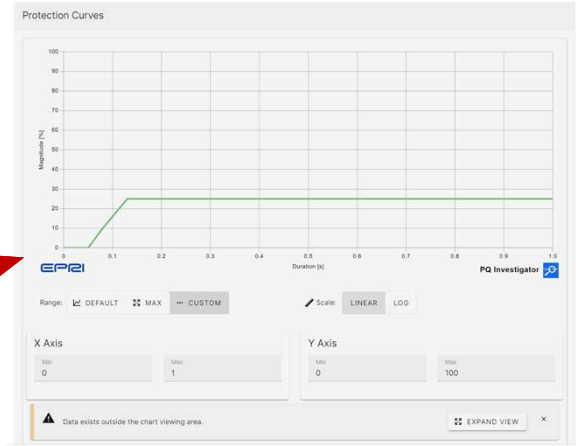
Mitigator Details: Description and Curve Anatomy





Protection Curves: Ability to toggle range, scale

Protection Curves: Ability to Customize Line

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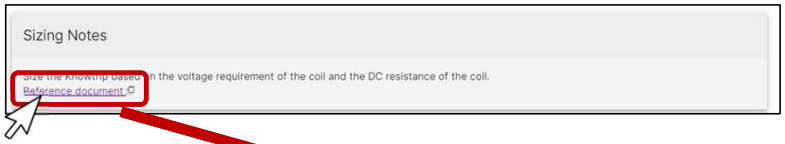
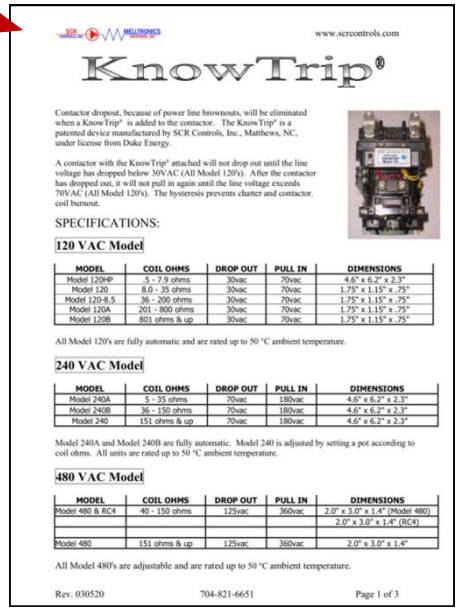
Mitigator Details: Sizing Notes and Publications



See Reference Documents hosted by Manufacturers in Sizing Notes (where Applicable)



www.scrcontrols.com

KnowTrip®

Contactor dropout, because of power line brownouts, will be eliminated when a KnowTrip® is added to the contactor. The KnowTrip® is a patented device manufactured by SCR Controls, Inc., Matthews, NC, under license from Duke Energy.

A contactor with the KnowTrip® attached will not drop out until the line voltage has dropped below 30VAC (All Model 120's). After the contactor has dropped out, it will not pull in again until the line voltage exceeds 70VAC (All Model 120's). The hysteresis prevents chatter and contactor coil burnout.

SPECIFICATIONS:

120 VAC Model

MODEL	COIL OHMS	DROP OUT	PULL IN	DIMENSIONS
Model 120HP	.5 - 7.9 ohms	30vac	70vac	4.6" x 6.2" x 2.3"
Model 120	8.0 - 35 ohms	30vac	70vac	1.75" x 1.15" x .75"
Model 120-8.5	36 - 200 ohms	30vac	70vac	1.75" x 1.15" x .75"
Model 120A	201 - 800 ohms	30vac	70vac	1.75" x 1.15" x .75"
Model 120B	801 ohms & up	30vac	70vac	1.75" x 1.15" x .75"

All Model 120's are fully automatic and are rated up to 50 °C ambient temperature.

240 VAC Model

MODEL	COIL OHMS	DROP OUT	PULL IN	DIMENSIONS
Model 240A	5 - 35 ohms	70vac	180vac	4.6" x 6.2" x 2.3"
Model 240B	36 - 150 ohms	70vac	180vac	4.6" x 6.2" x 2.3"
Model 240	151 ohms & up	70vac	180vac	4.6" x 6.2" x 2.3"

Model 240A and Model 240B are fully automatic. Model 240 is adjusted by setting a pot according to coil ohms. All units are rated up to 50 °C ambient temperature.

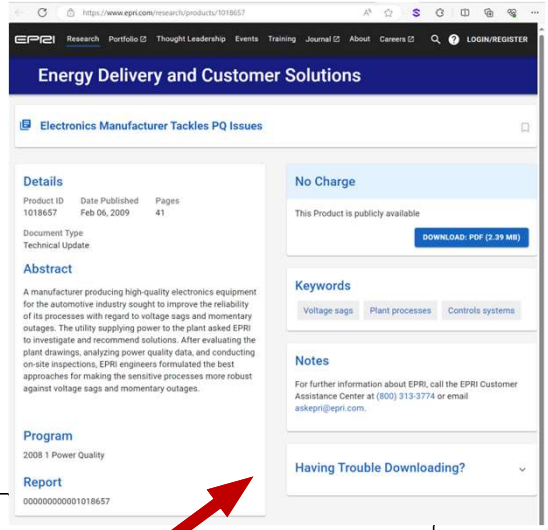
480 VAC Model

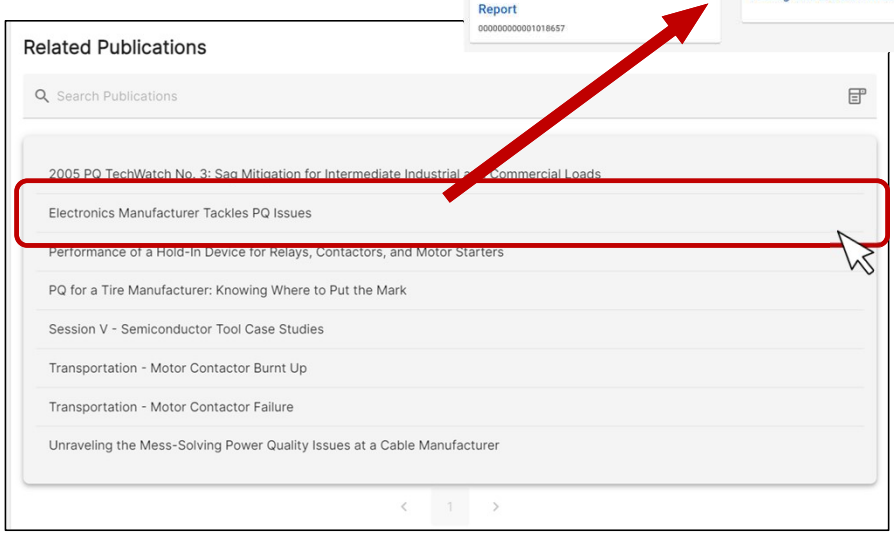
MODEL	COIL OHMS	DROP OUT	PULL IN	DIMENSIONS
Model 480 & RC4	40 - 150 ohms	125vac	360vac	2.0" x 3.0" x 1.4" (Model 480)
				2.0" x 3.0" x 1.4" (RC4)
Model 480	151 ohms & up	125vac	360vac	2.0" x 3.0" x 1.4"

All Model 480's are adjustable and are rated up to 50 °C ambient temperature.

Rev. 030520 704-821-6651 Page 1 of 3

See Research Publications hosted by EPRI.com in Publications (where Applicable)





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Mitigator Details: Mitigator Type, Related Mitigators, and Cost

Mitigator Type: Coil Hold-In Device ← Mitigator Type Name

The Coil Hold-In Device has the ability to keep any device controlled by an AC coil energized through voltage sags down to 25% nominal voltage. Some suppliers also include surge suppression in the design to mitigate lightning and switching induced transients on the coil of the AC relay, contactor, or motor starter. Typically the device is connected between the control signal that normally powers the relay, motor starter, or contactor coil and the coil itself as shown in the figure below. The final sizing of these devices is based on the coil voltage and the DC coil resistance.

Mitigator Type Icon

Mitigator Type Description

Related Mitigators

Search Mitigators

Coil-Lock

KnowTrip 240V

KnowTrip 480V

Mitigators that share the same Mitigator Type as the selected Mitigator

Mitigator Costs

Manufacturer	Part Number	Description	Cost
SCR Controls Inc.	MODEL 120	MODEL 120 8.0 - 35 OHMS, 50/60Hz	$268
SCR Controls Inc.	MODEL 120-8.5	MODEL 120-8.5 36 - 200 OHMS, 50/60Hz	$268
SCR Controls Inc.	MODEL 120A	MODEL 120A 201 - 800 OHMS, 50/60Hz	$268
SCR Controls Inc.	MODEL 120B	MODEL 120B 801 OHMS and UP, 50/60Hz	$268
SCR Controls Inc.	MODEL 120HP	MODEL 120HP .5 - 7.9 OHMS, 50/60Hz	$696

Items per page: All 1-5 of 5

Navigate Costs with Manufacturer, Part Number, and Description Information

Sola MCR Series CVT: Demonstration of Mitigator Costs potential scale

Mitigator Costs

Manufacturer	Part Number	Description	Cost
SOLA-Hevi-Duty	63-23-112-4	CVT, MCR Series, 0.12kVA, Input 120,208,240,480V, Output 120V Tap, 1A, 60Hz	$500
SOLA-Hevi-Duty	63-23-125-4	CVT, MCR Series, 0.25kVA, Input 120,208,240,480V, Output 120V Tap, 2A, 60Hz	$600
SOLA-Hevi-Duty	63-23-150-8	CVT, MCR Series, 0.5kVA, Input 120,208,240,480V, Output 120V Tap, 4.2A, 60Hz	$900
SOLA-Hevi-Duty	63-23-150-8	CVT, MCR Series,0.5kVA, Input 120,208,240,480V, Output 208V Tap, 2.4A, 60Hz	$900
SOLA-Hevi-Duty	63-23-150-8	CVT, MCR Series, 0.5kVA, Input 120,208,240,480V, Output 240V Tap, 2.1A, 60Hz	$900
SOLA-Hevi-Duty	63-23-175-8	CVT, MCR Series,0.75kVA, Input 120,208,240,480V, Output 120V Tap, 6.3A,60Hz	$1,100
SOLA-Hevi-Duty	63-23-175-8	CVT, MCR Series,0.75kVA, Input 120,208,240,480V, Output 208V Tap, 3.6A, 60Hz	$1,100
SOLA-Hevi-Duty	63-23-175-8	CVT, MCR Series, 0.75kVA, Input 120,208,240,480V, Output 240V Tap, 3.1A, 60Hz	$1,100
SOLA-Hevi-Duty	63-23-210-8	CVT, MCR Series, 1kVA, Input 120,208,240,480V, Output 120V Tap, 8.3A, 60Hz	$1,400
SOLA-Hevi-Duty	63-23-210-8	CVT, MCR Series, 1kVA, Input 120,208,240,480V, Output 208V Tap, 4.8A, 60Hz	$1,400
SOLA-Hevi-Duty	63-23-210-8	CVT, MCR Series, 1kVA, Input 120,208,240,480V, Output 240V Tap,4.2A, 60Hz	$1,400

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Things you can do from the Navigator Page

- Select and view sequential info on:
  - An Industry
    - Related Processes
    - Related Equipment
    - Associated Components
- For components:
  - Select and view info on a component
  - Select a manufacturer
    - Go to Manufacturer web site
    - View a list of all components in the PQI DB from that manufacturer
    - Go to cut sheet for component
- For mitigators:
  - Select and view info on Mitigators
  - Select a manufacturer
    - Go to manufacturer web site
    - View a list of all mitigators in the PQI DB from that manufacturer

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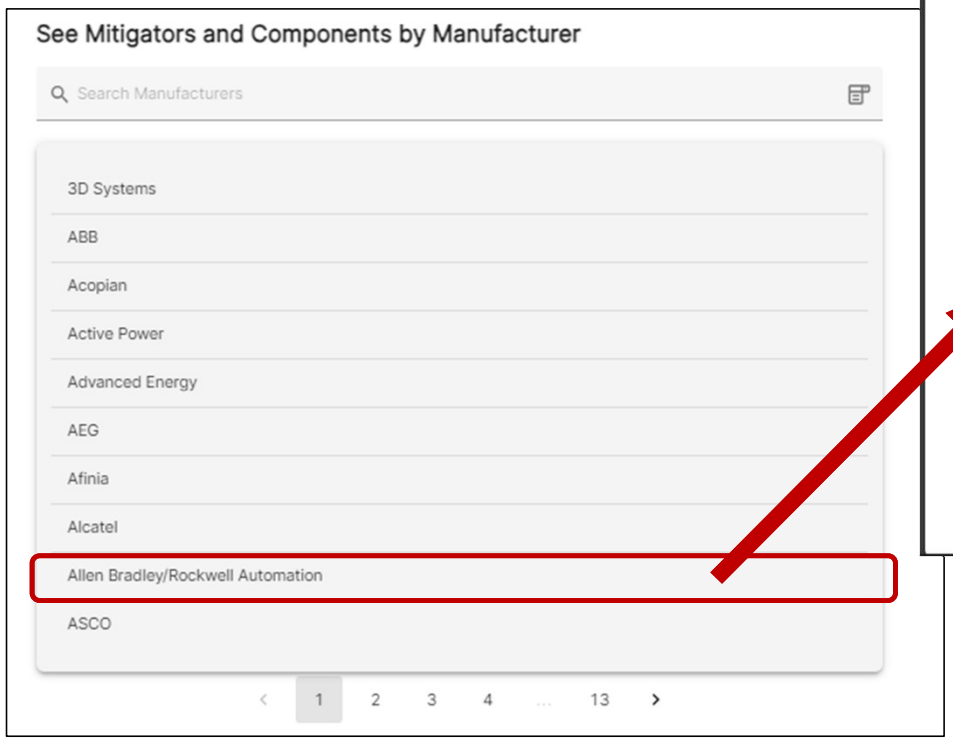
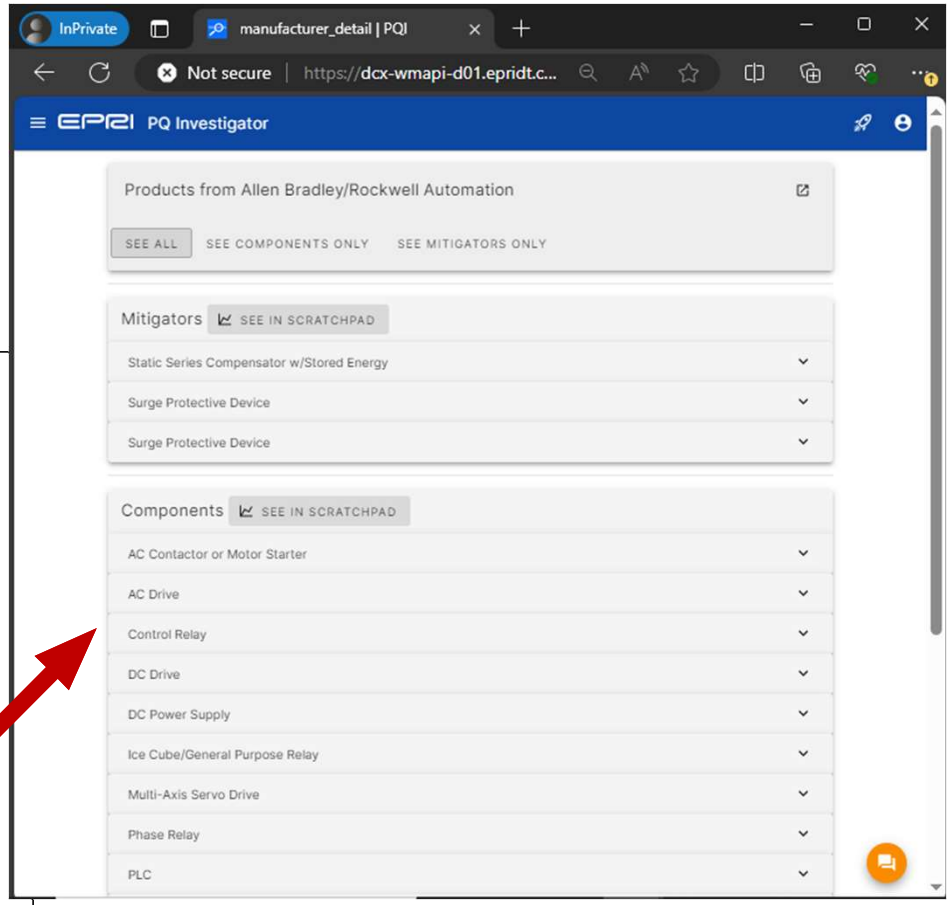
See All Products by a given Manufacturer





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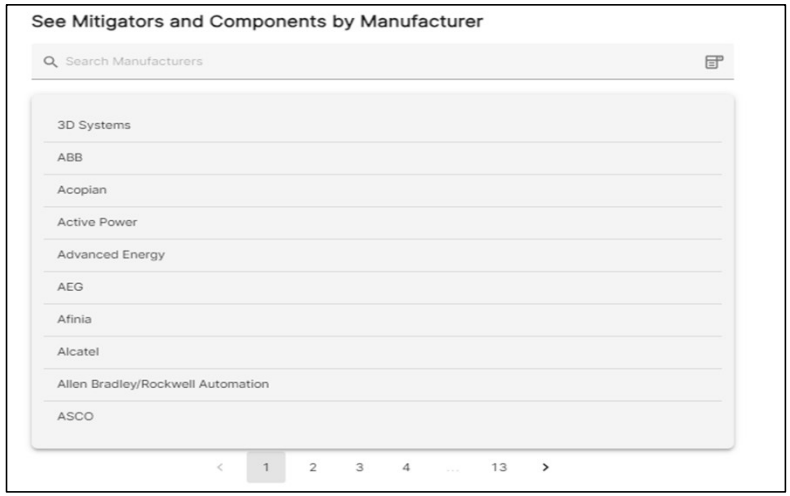
Manufacturer Recap: Where to find Manufacturer Information?



The Manufacturer Page on the Navigator Home Page

The Component Type Page, under the Manufacturers Section

The Mitigator Page, under the Manufacturers Section

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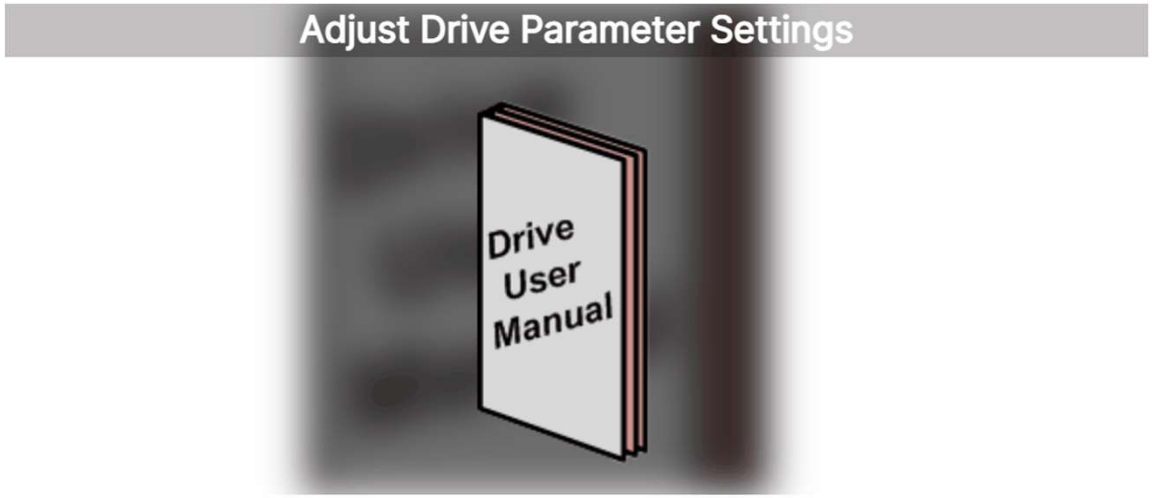
New Layout: Meatballs on Top

Database currently includes 45 Mitigators and constantly growing to include more



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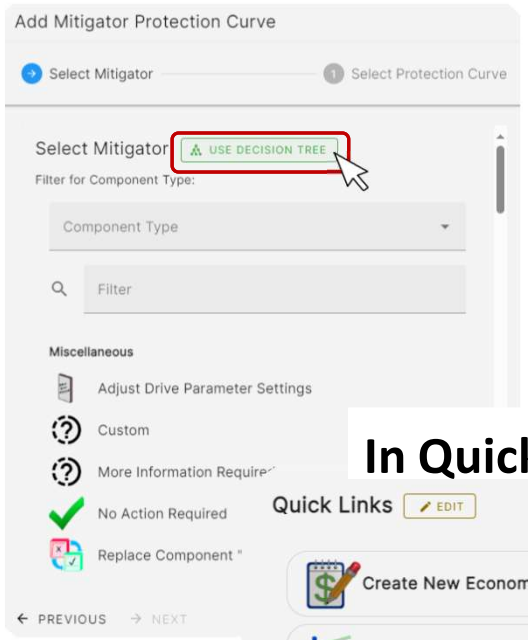
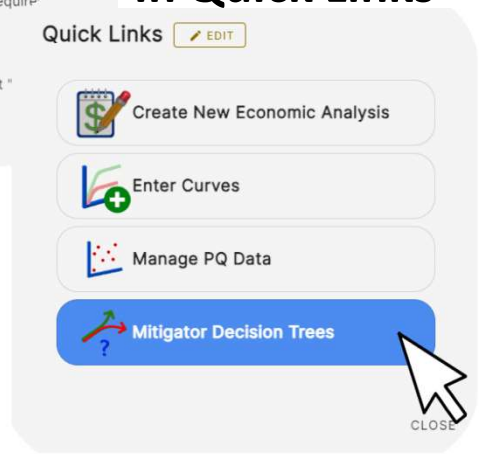
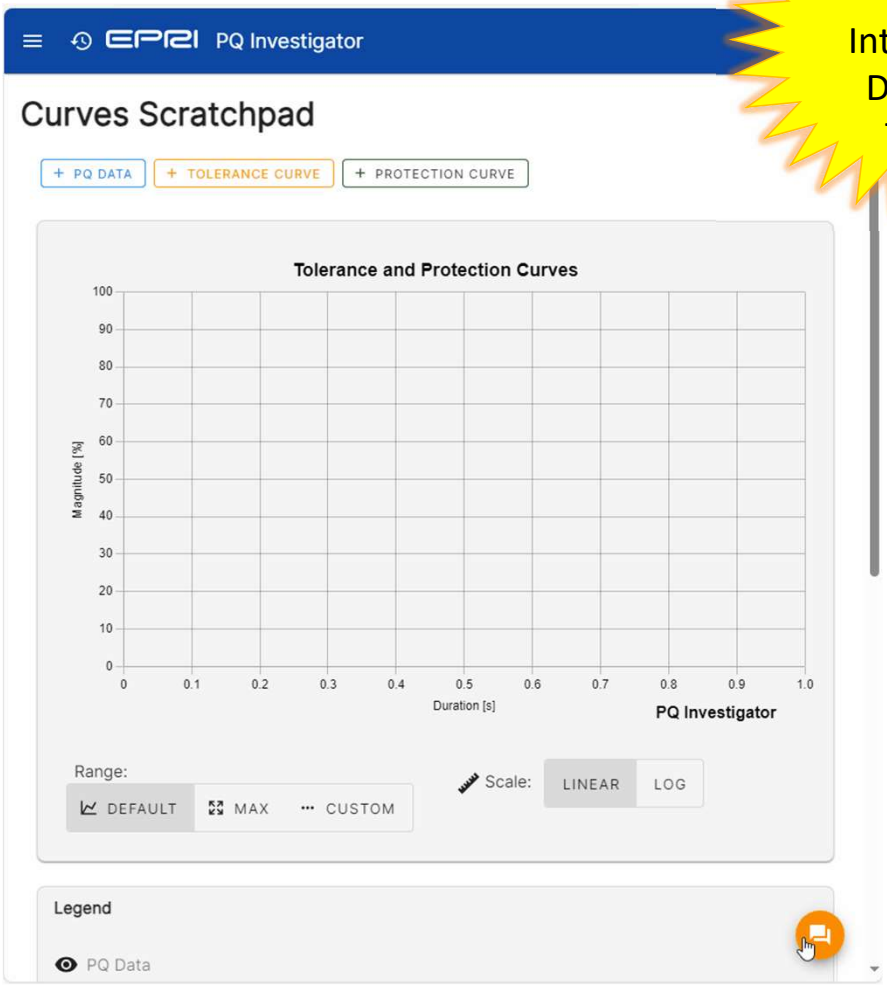
Where to Find Decision Trees in PQI….

In Curves Module



In Quick Links





New in V4.0: Interactive Decision Trees!

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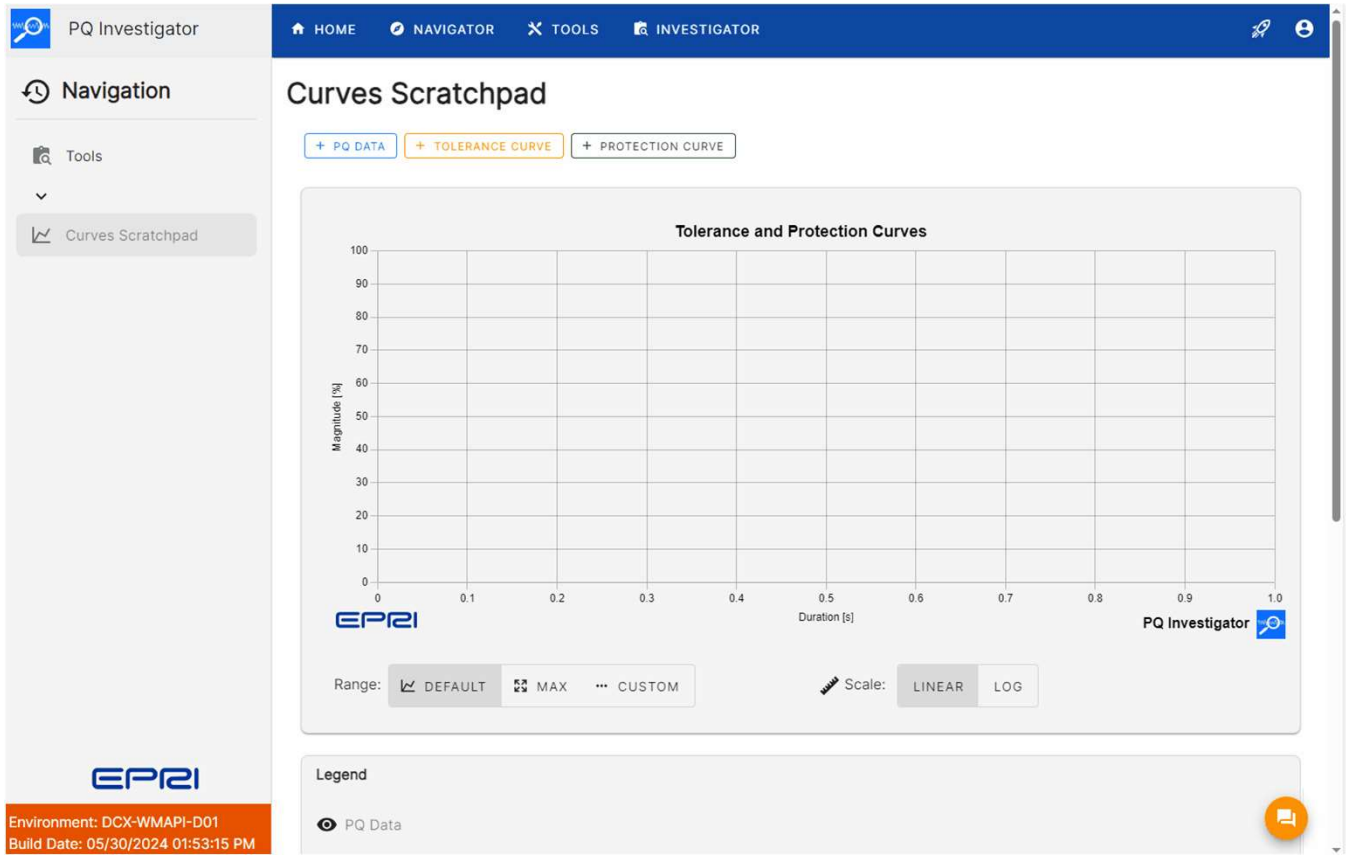
Demo New Interactive Mitigation Decision Trees



Automatically Select Protection Curves for Mitigators

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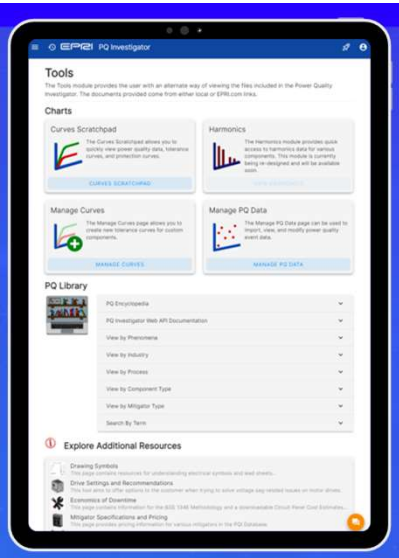
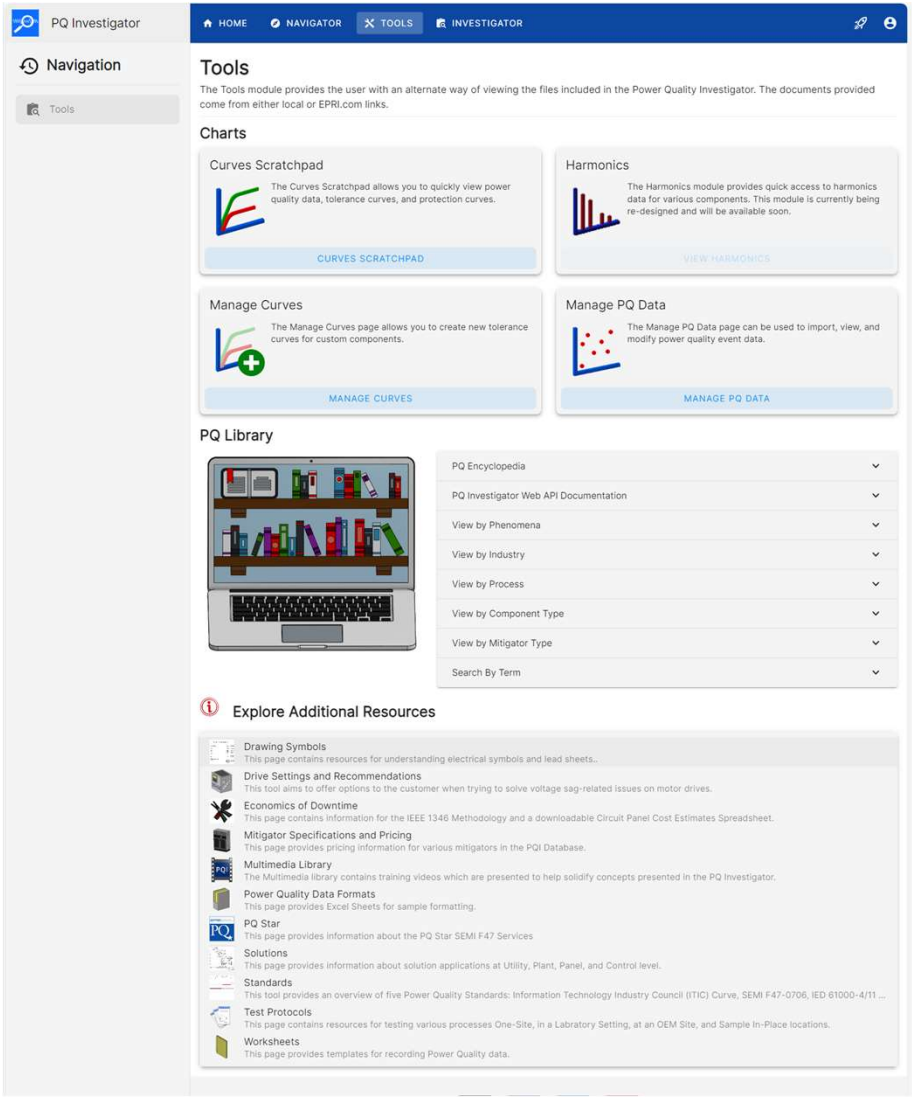


Tools Module Demo/Class Participation

Tools Module



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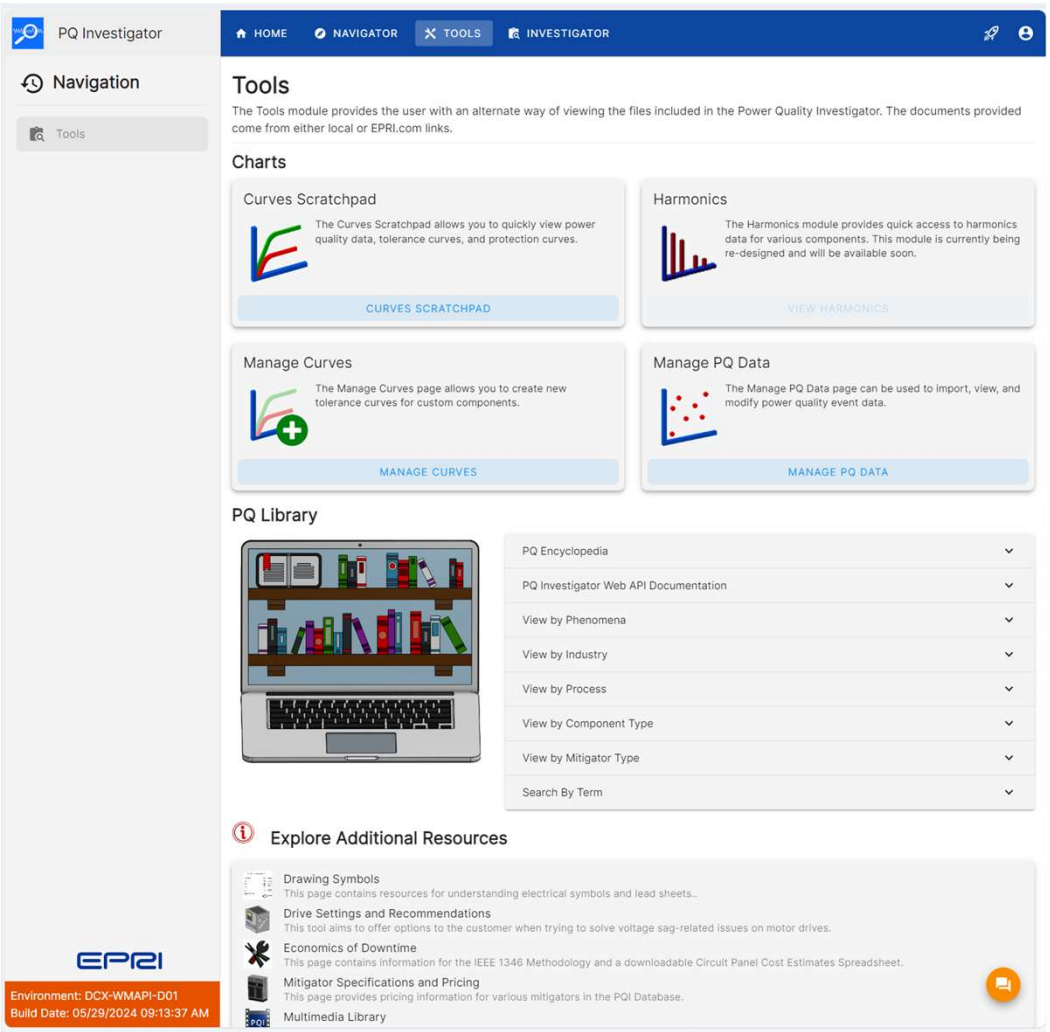
Breakout of Tools Module

- Access to various functions:
  - Curve Functions
    - Curves Scratchpad
    - View Harmonics
    - Enter Curves
    - Manage PQ Data
  - EPRI PQ Library
    - Library Module Function built in throughout PQI
    - Searchable on topics, phenomena, industry, process, component, etc.
    - Pulls docs from EPRI.com or directly from PQI
  - Additional Resources:
    - Multimedia Library
    - Drive Settings and Recommendations
    - Mitigator Specifications and Pricing
    - …



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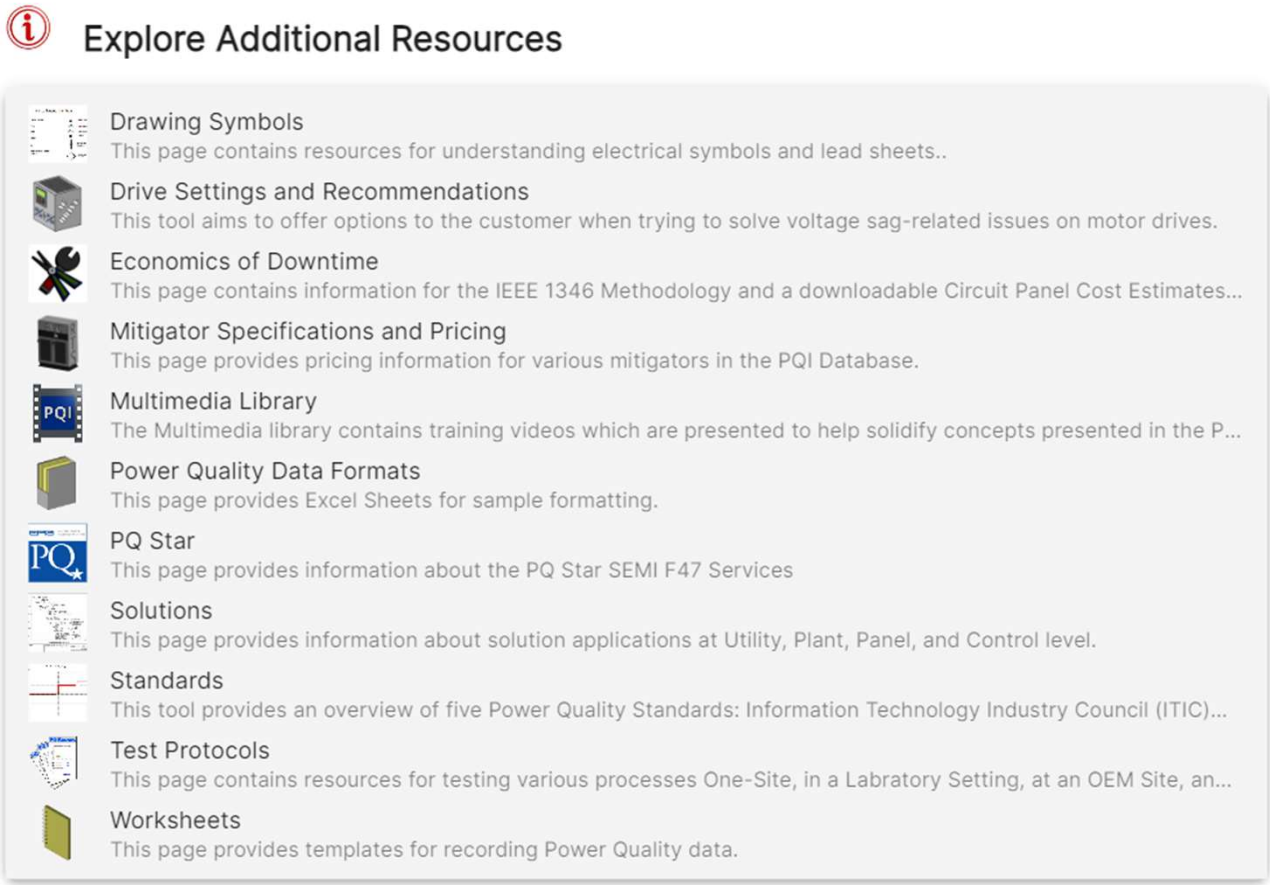
Breakout of Tools Module (Continued)

- Additional Resources:
  - Drawing Symbols
  - Drive Settings and Recommendations
  - Economics of Downtime
  - Mitigator Specifications and Pricing
  - Multimedia Library
  - Power Quality Data Formats
  - PQ Star
  - Solutions
  - Standards
  - Test Protocols
  - Worksheets



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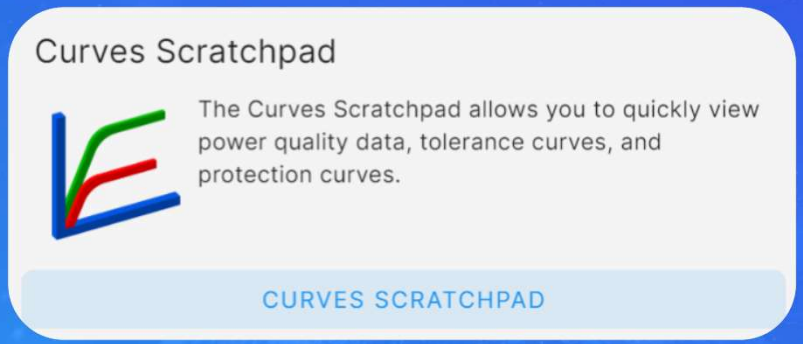
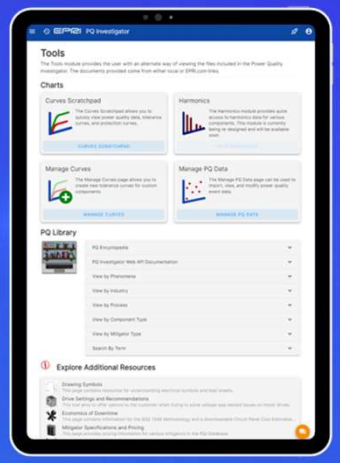


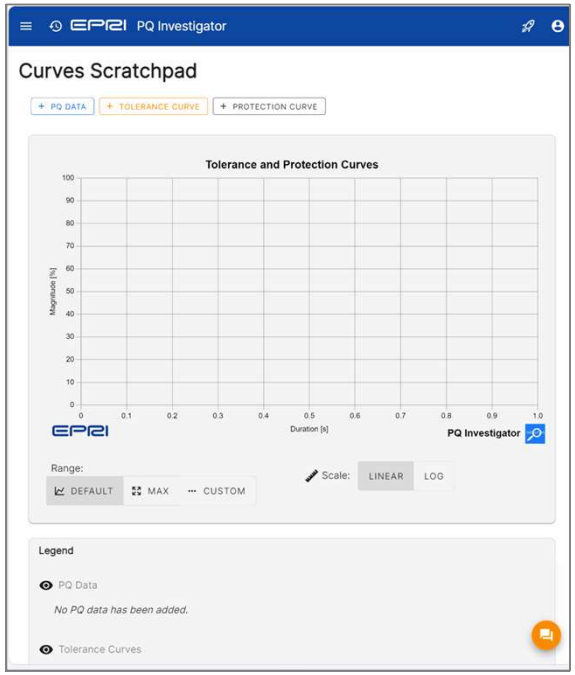
Curves Scratchpad Tool



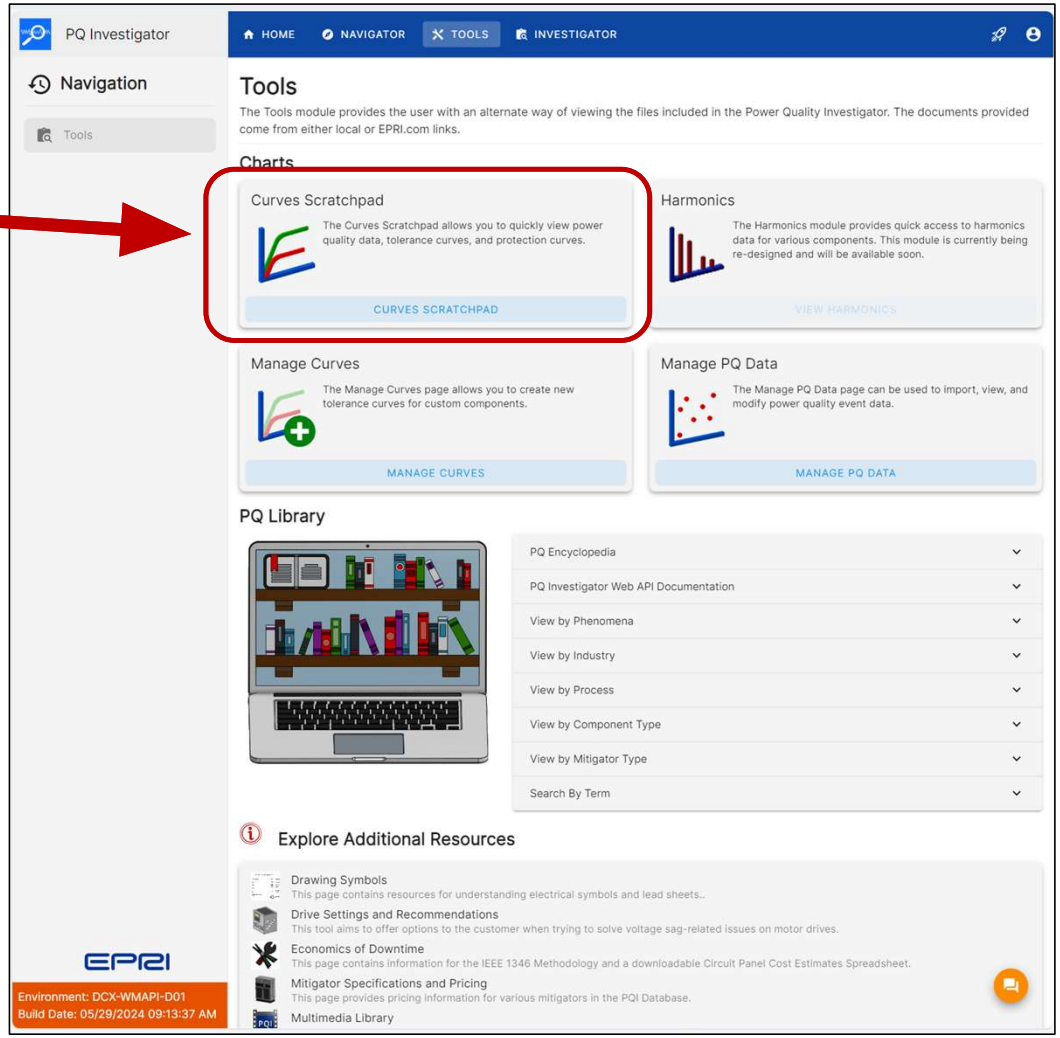
Tools Module

Curves Scratchpad

View Ride-Through Curves, Mitigator Curves, & PQ Data



Allows for Construction of Ride-Through Curves, mitigator protection curves, and overlay of PQ data.



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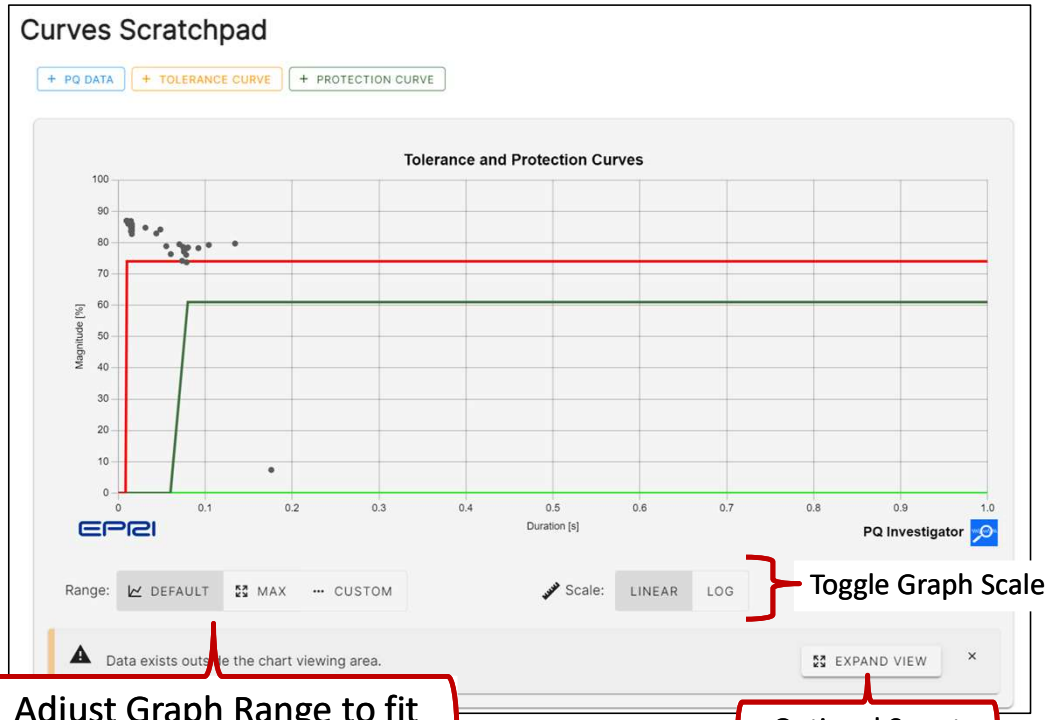
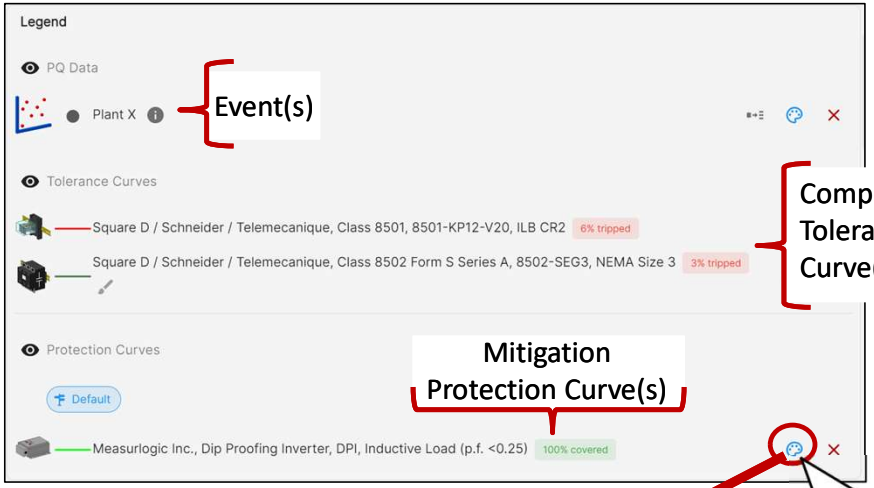
Tools Module – Curves Scratchpad

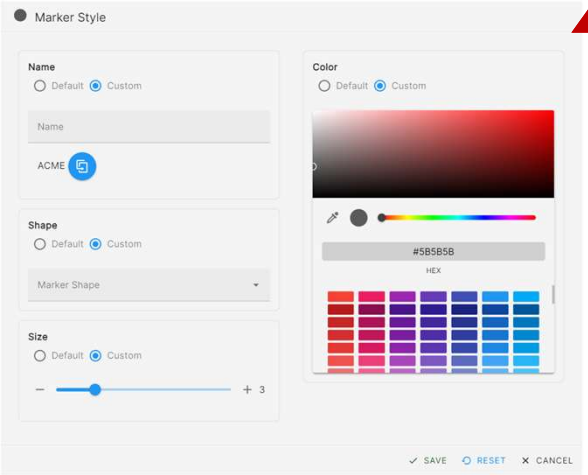


Toggle Graph Scale

Adjust Graph Range to fit your needs
(Also adjustable via dragging)

Optional Smart Adjustment if Data exists outside of your selected range





Customize the Name, Shape, Size, and Color of PQ Data Points and Curve Lines

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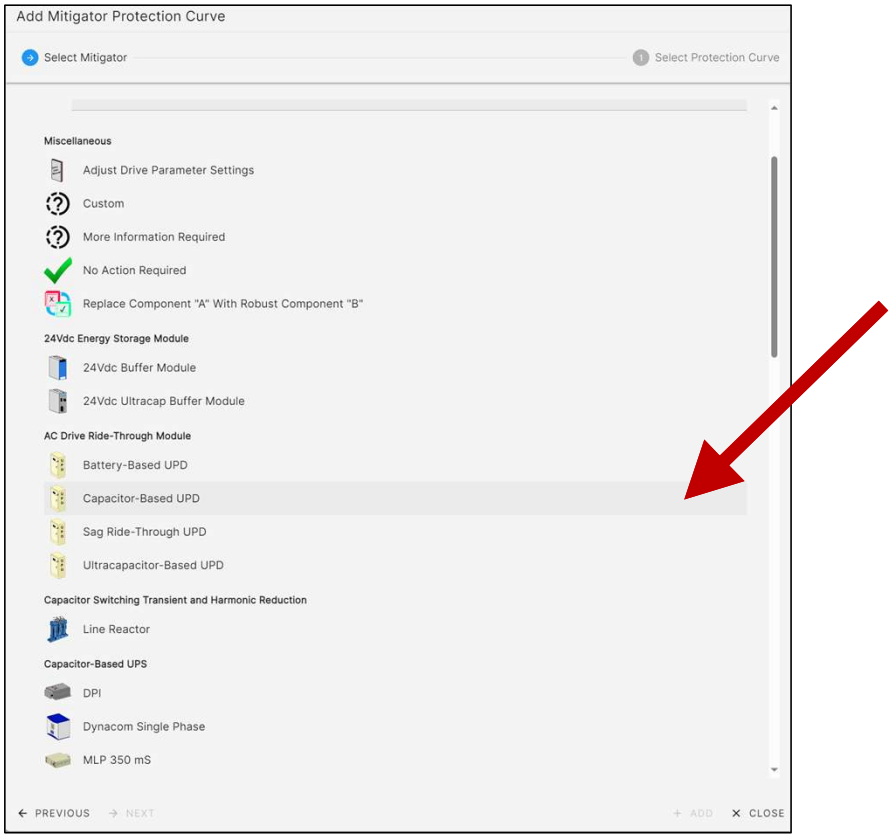
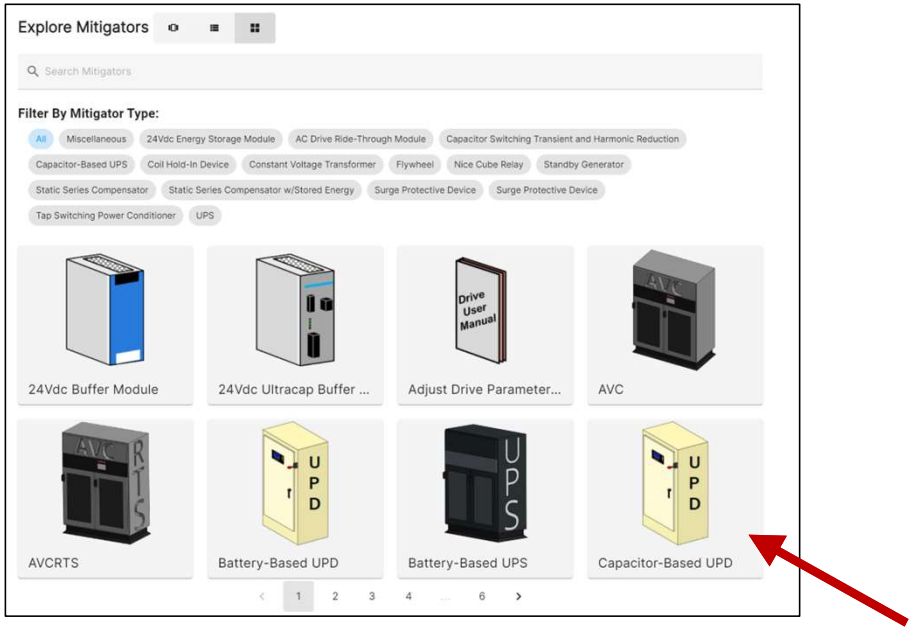
“Meatballs on Top” View for Mitigators



- New Feature: Implemented in Mitigator Specifications and Navigator



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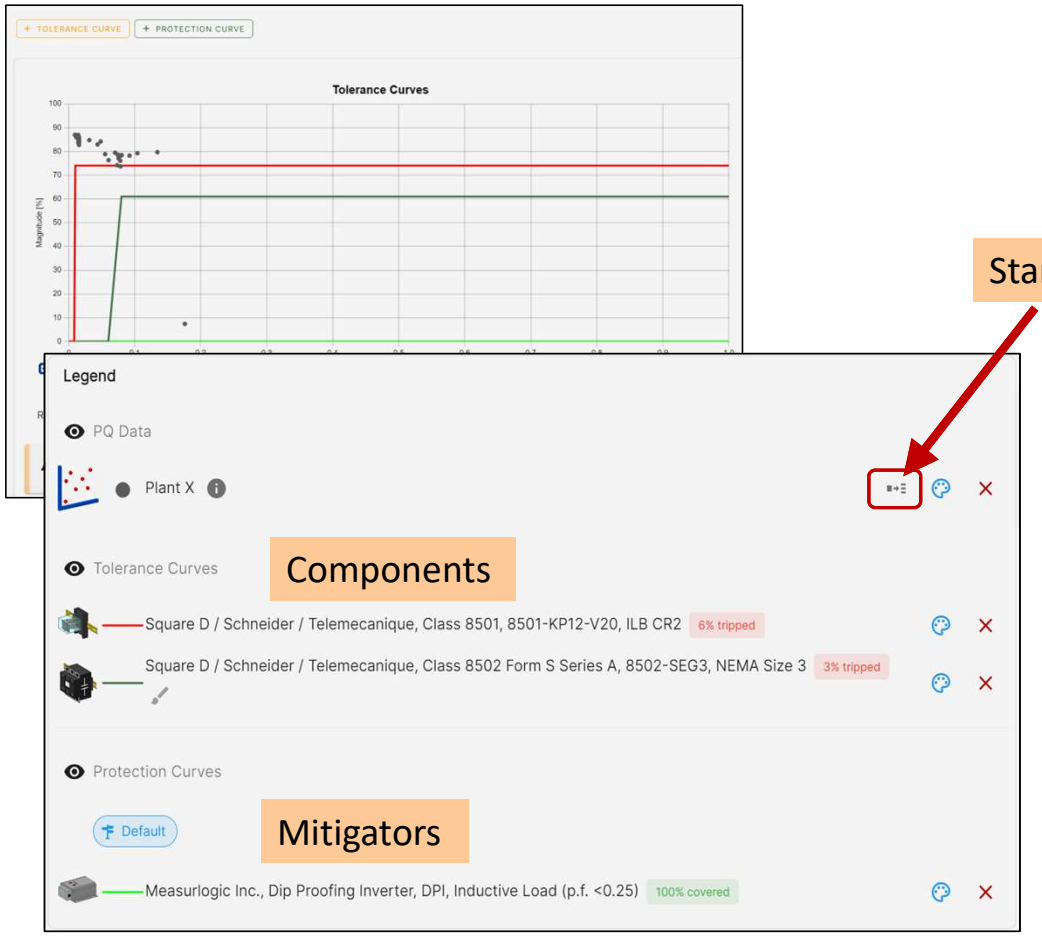
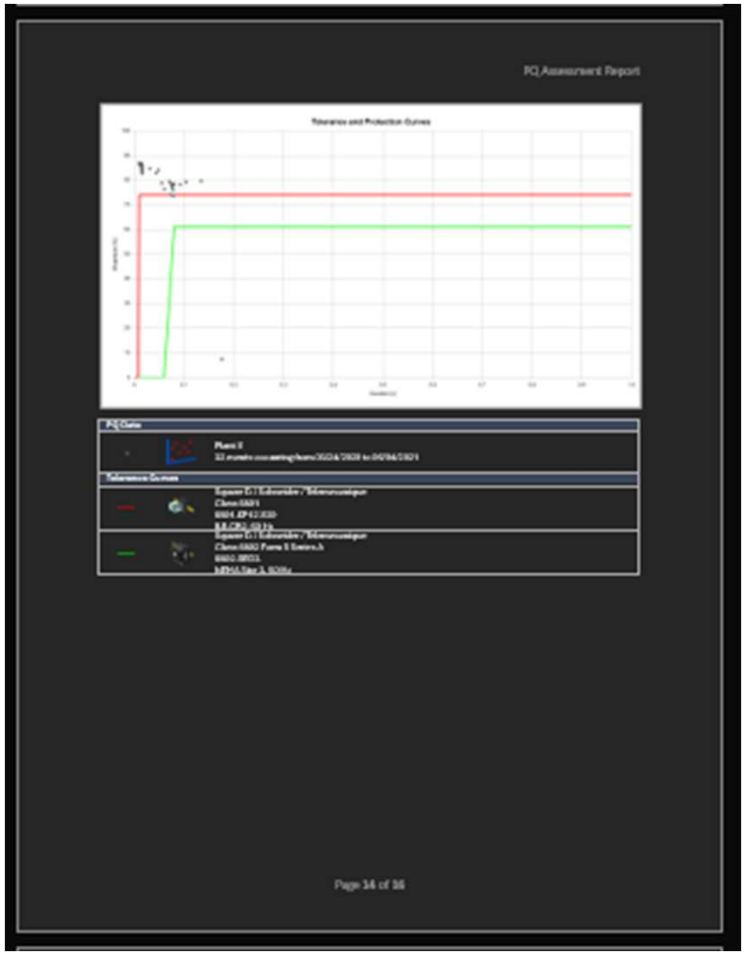
Curves – Show Both Percent Coverage and Percent Trip Calculations

Curves Page



Generated Report



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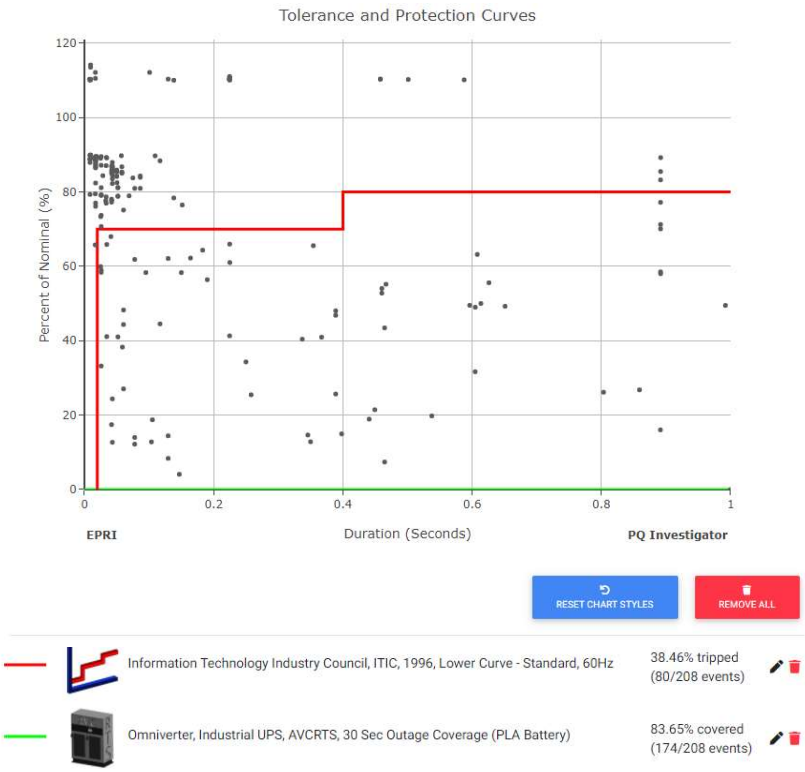
Coverage Model Refinements

- In most cases, the coverage accurately calculates.
- There are some cases where that may not be the case for OV transient and OV Swell event coverage
  - EPRI refining on a case-by-case basis.
    - User can choose not to include these coverage percentages in the report (See next Slide)
  - Example case in point:
    - For events longer than ¼ cycle AVS RTS is default is +10%/-10% but can be changed. Still need Surge Protection for Lightning Strike (microsecond events)
    - Not currently accurately presented if you have OV or Swell in your PQ dataset.



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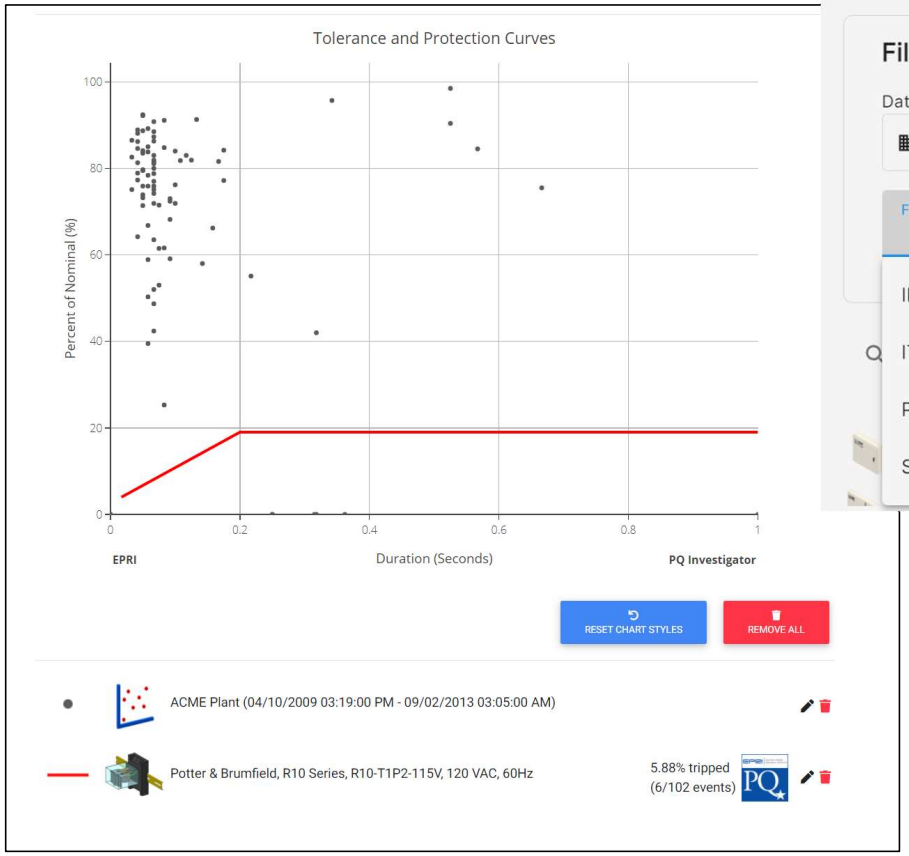
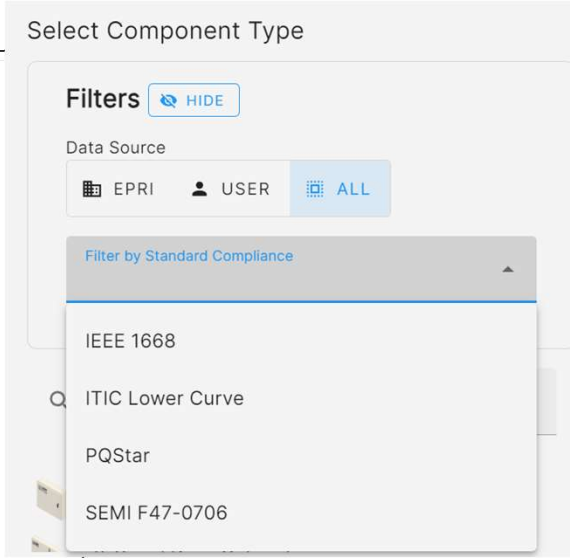
Allows Search for SEMI F47/IEEE 1668/ITIC Lower Curve with a Better Component





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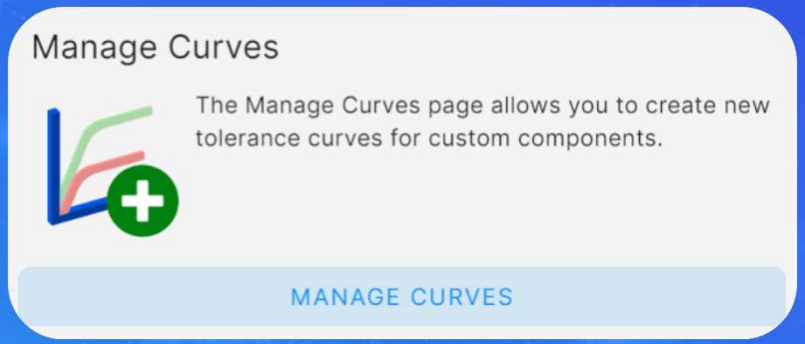
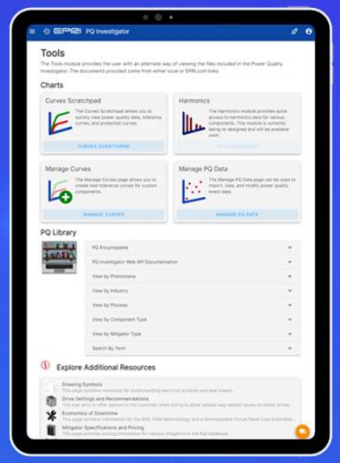
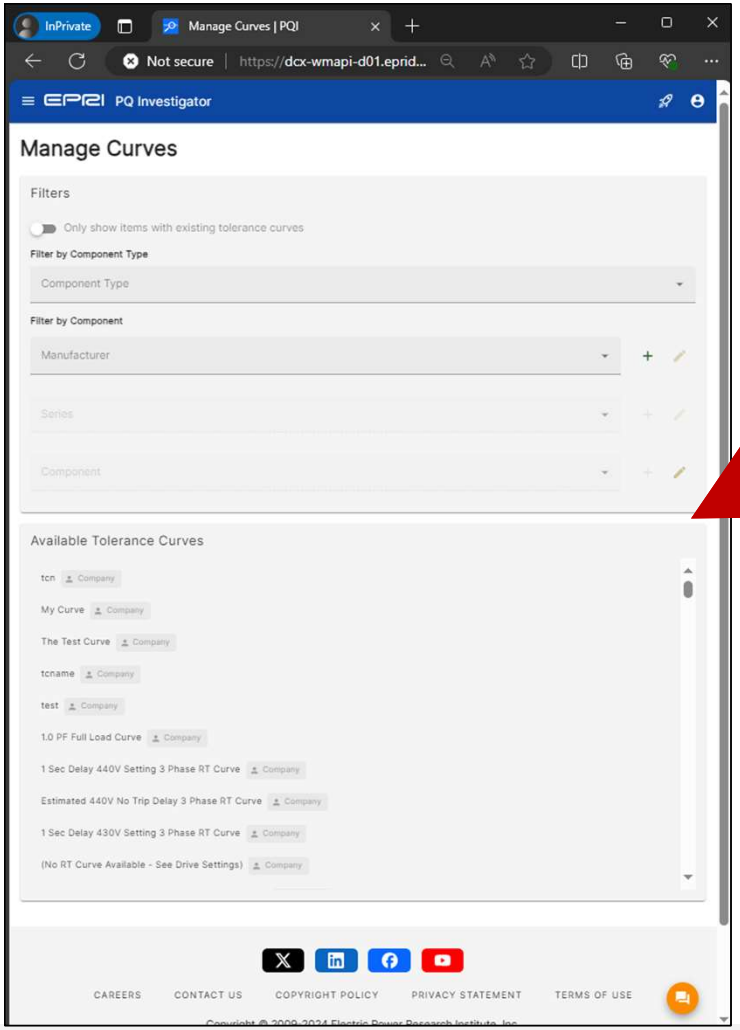
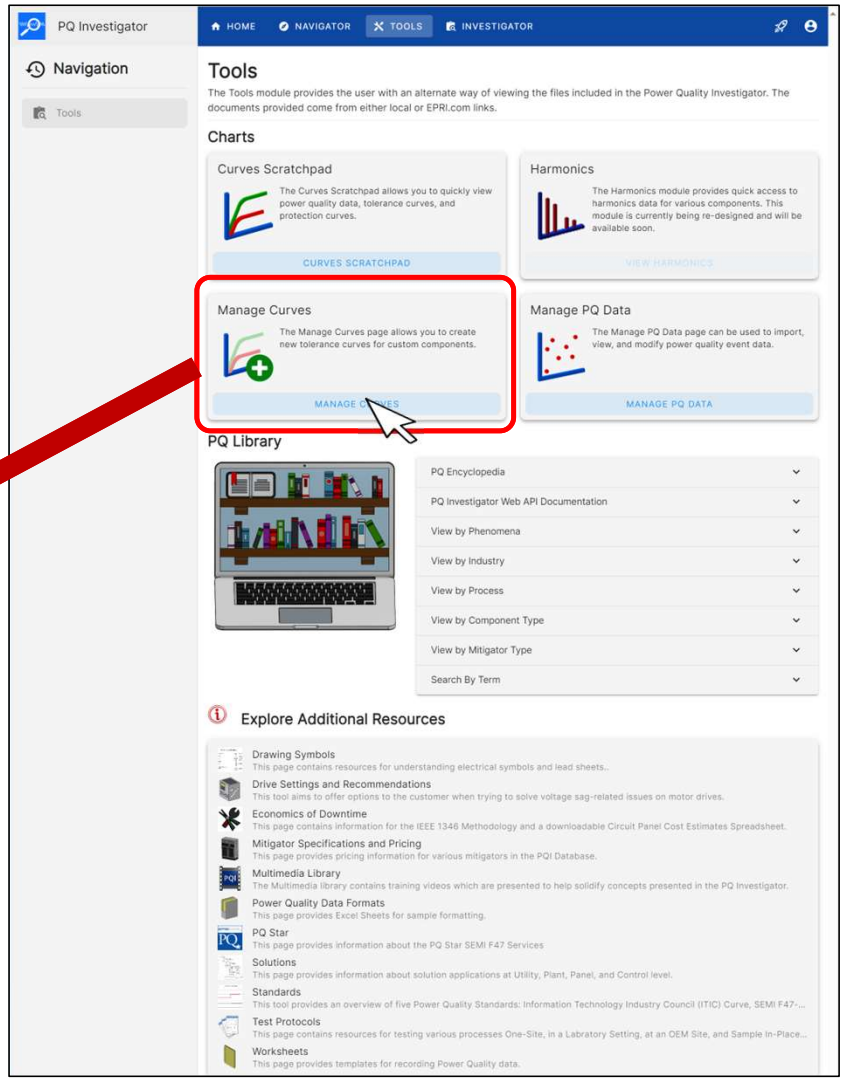




Manage Curves Tool

Tools Module: Manage Curves





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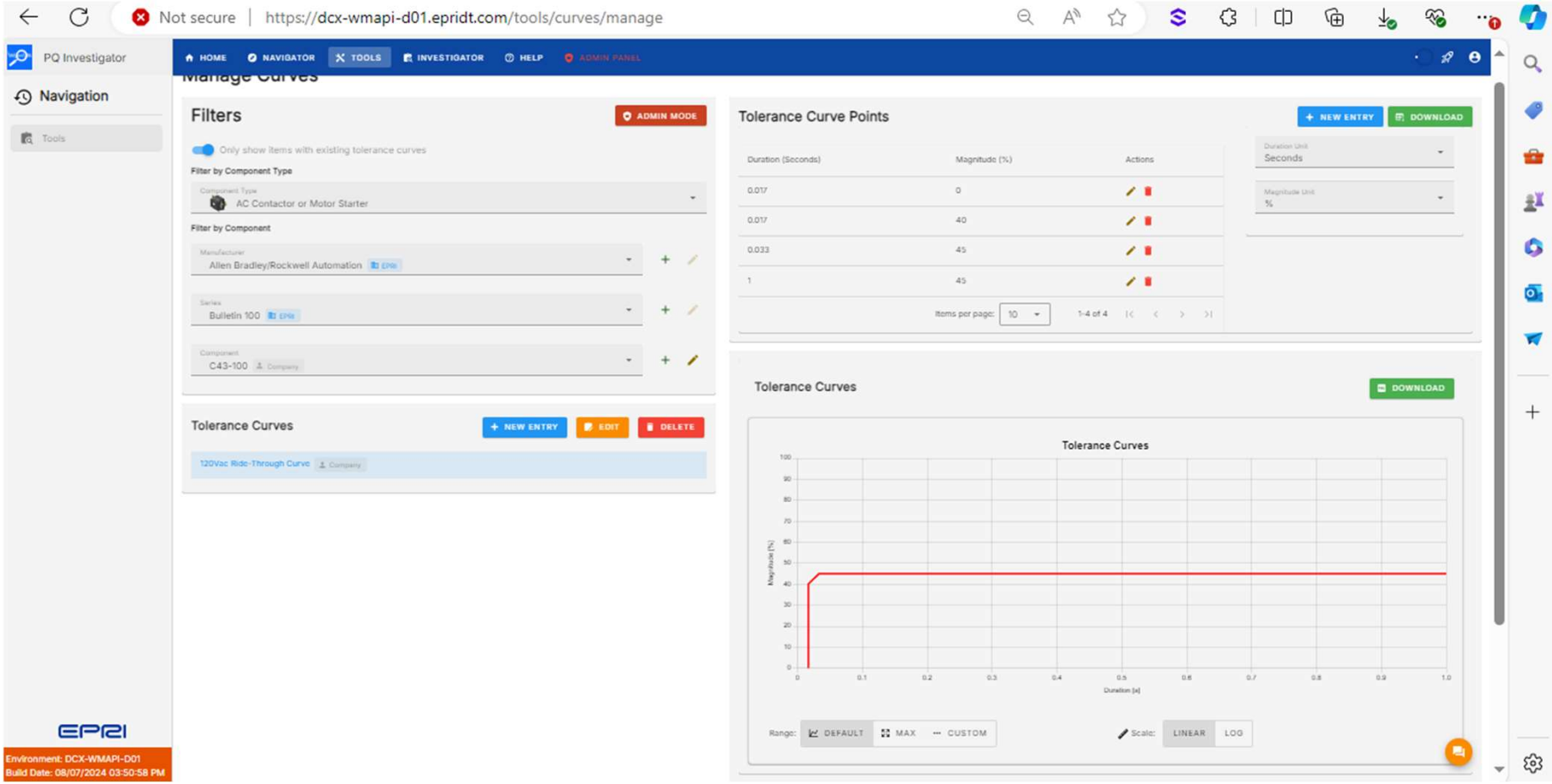
See the Tolerance Curves based on Component Type, Manufacturer, Series, and Component



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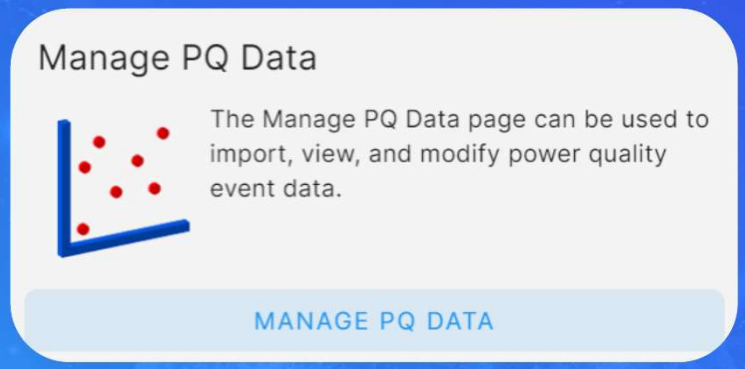
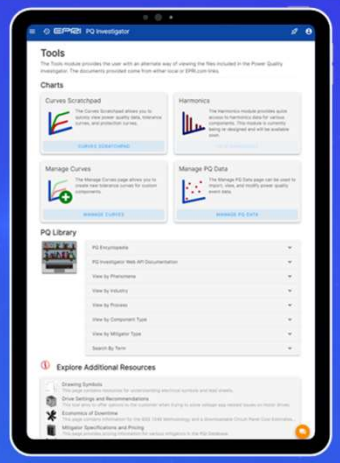
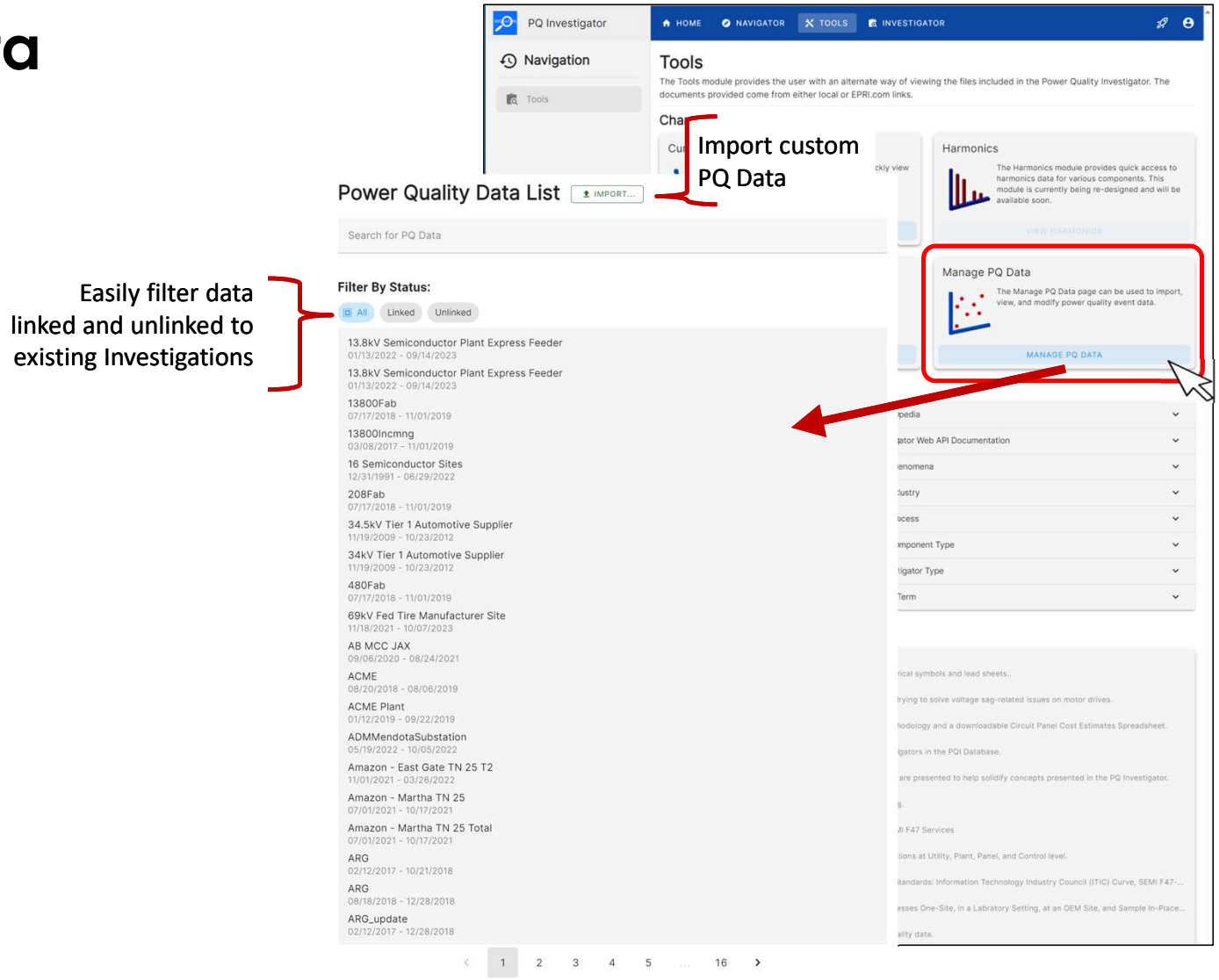




Manage PQ Data Tool

Managing PQ Data

- To manage your PQ data, you must first import it into the PQI
- This assumes you either have the data formatted in a supported format
- In this section, we will explain how to import and manage this data
- This function allows the user to manage PQ Data sets including the ability to:
  - Import data
  - Delete data
  - Add Comments
  - View Statistics



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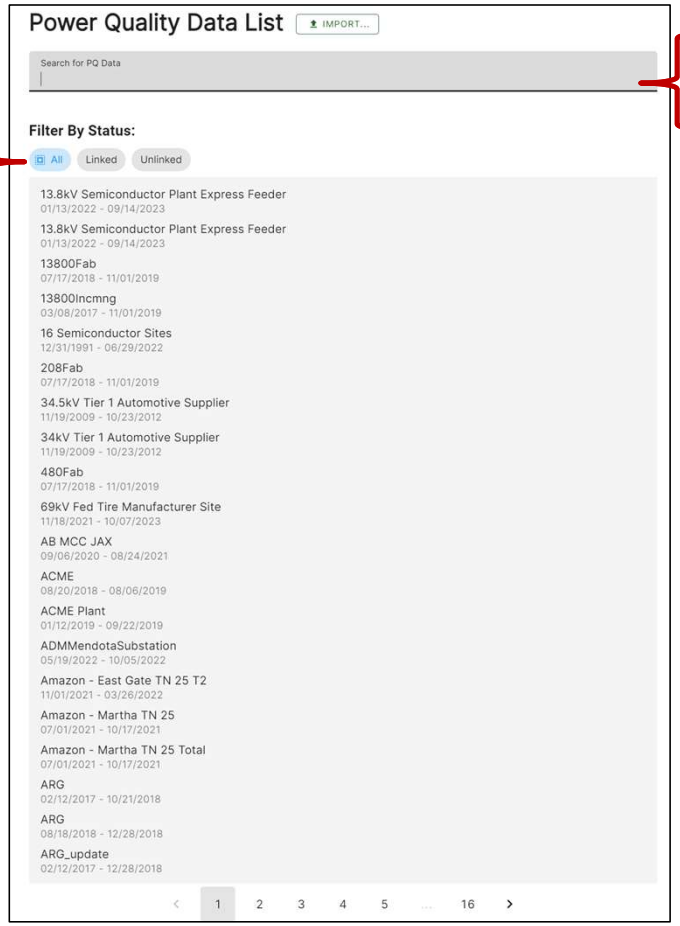
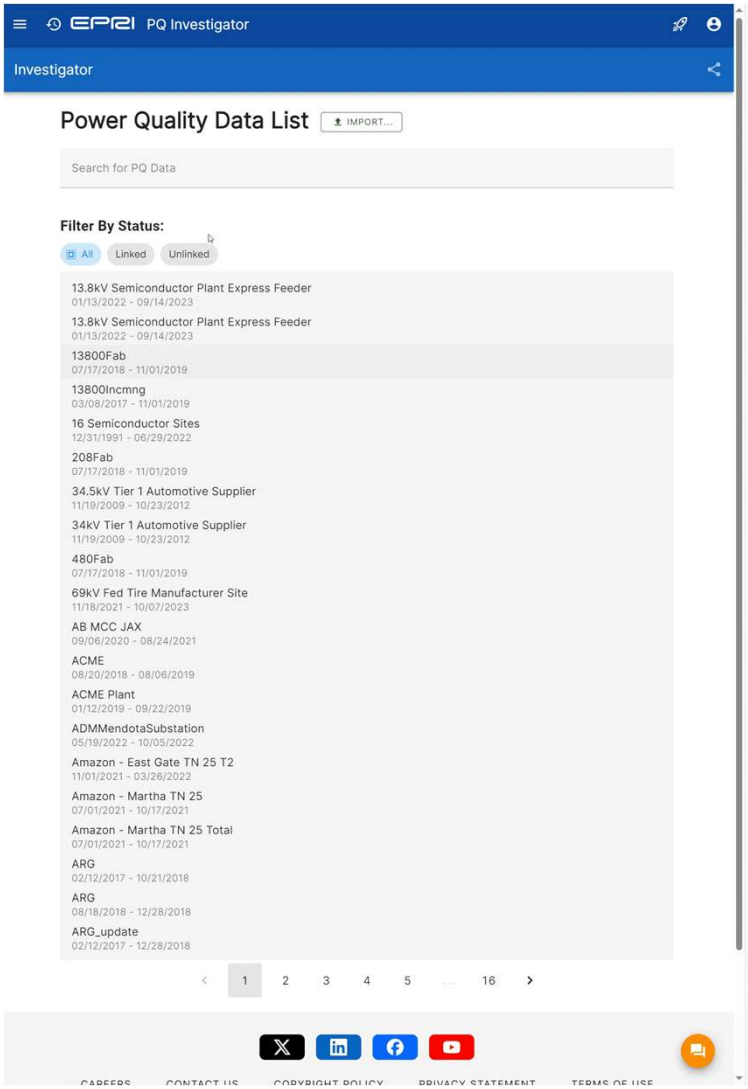
Viewing Existing Data

filter data linked and unlinked to existing Investigations



Search PQ Data by name



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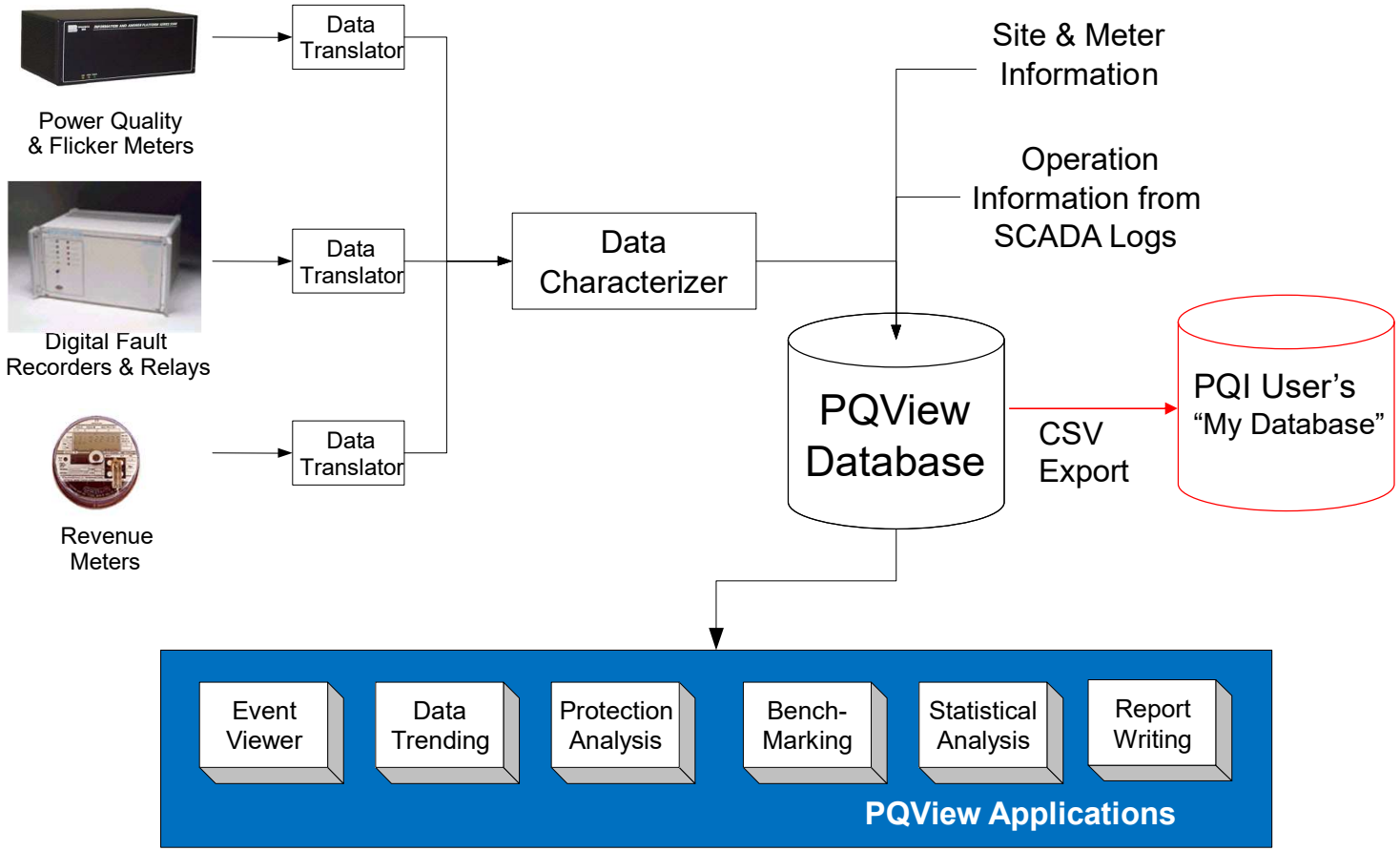
PQ View 3.X Export – PQ Investigator Import Example



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Additional Resources: Anatomy of Downloadable Content

Power Quality Data Formats

- Power Quality Investigator (PQI) v2 Format — DOWNLOAD
- PQView Format — DOWNLOAD
- PQWeb 4.x Format — DOWNLOAD
- Ion Format — DOWNLOAD
- I-Grid Format — DOWNLOAD
- MAXsys Format — DOWNLOAD

Save Files directly to your Local Machine

EPRI's SEMI F47 PQ Star Listing

To serve the semiconductor industry, EPRI created the PQ Star certification program to test manufacturer equipment per established power quality standards. EPRI began conducting PQ Star certification for the SEMI F47 standard in 2000. The link to the right opens a spreadsheet that lists the components and equipment that have been certified as a part of the PQ Star program. The listing includes a wide array of components and equipment, including power conditioners, power supplies, relays and contactors, vacuum pumps, variable frequency drives (ASDs), and semiconductor tools and sub-equipment. The listing also contains contact information for the OEMs who have compliant products. The actual certification documentation can be obtained by requesting a copy from the OEM.

The password for the spreadsheet is "PQ! marks.

Drawing Symbols

Drawing Symbols and Lead Sheets

This PDF contains common Electrical Symbols, ISA Nomenclature, an example Process Flow Diagram, an example Piping and Instrumentation Diagram/Drawing (P&ID), and a Loop Diagram example. This PDF is related to the Industrial Systems Training video.

VIEW DOWNLOAD

View Links in New Tabs

Explore Additional Resources

- Drawing Symbols — This page contains resources for understanding electrical symbols and lead sheets..
- Drive Settings and Recommendations — This tool aims to offer options to the customer when trying to solve voltage sag-related issues on motor drives.
- Economics of Downtime — This page contains information for the IEEE 1346 Methodology and a downloadable Circuit Panel Cost Estimates...
- Mitigator Specifications and Pricing — This page provides pricing information for various mitigators in the PQI Database.
- Multimedia Library — The Multimedia library contains training videos which are presented to help solidify concepts presented in the P...
- Power Quality Data Formats — This page provides Excel Sheets for sample formatting.
- PQ Star — This page provides information about the PQ Star SEMI F47 Services
- Solutions — This page provides information about solution applications at Utility, Plant, Panel, and Control level.
- Standards — This tool provides an overview of five Power Quality Standards: Information Technology Industry Council (ITIC)...
- Test Protocols — This page contains resources for testing various processes One-Site, in a Labratory Setting, at an O...
- Worksheets — This page provides templates for recording Power Quality data.

Drive Settings and Recommendations

This PowerPoint file contains many of the power quality related settings for common drives used in industry. The purpose of this file is to help the PQ Investigator offer options to the customer when they are trying to solve voltage sag related issues on their motor drives. This list of drives and power quality settings will be updated in successive releases of the Power Quality Investigator.

POWERPOINT VERSION | PDF VERSION

Choose Between File Formats

Worksheets

PQ Audit / Walkthrough - Equipment Worksheet

This worksheet is designed to facilitate an on-site audit of customer equipment for power quality issues. The worksheet has sections for noting the equipment profile, power specifications and measurements, control power specifications and measurements, the specific controller information and I/O power source, and a notes section. This is one of the most frequently used worksheets by EPRI when conducting power quality work at customer sites.

VIEW DOWNLOAD

Equipment Specifications Worksheet

This is a worksheet that can be used to document details about a specific piece of equipment from the nameplate data, correlation to drawings, power feed, interlocks, etc. This is a variant of the equipment profile in the PQ Audit/Walkthrough Worksheet.

VIEW DOWNLOAD

Equipment Response Worksheet

This worksheet is designed to obtain the specific details of how a machine or equipment responds to power quality events. It provides a detailed checklist that will help the PQ Engineer better understand what the customer's equipment is experiencing during PQ events.

VIEW DOWNLOAD

Steady State Measurement Worksheet

This worksheet is often used to document the electrical parameters and power profile of a machine or equipment before voltage sag testing is conducted. This is important as the results of the test could depend on the nominal voltage at the time of the test, load on the machine, etc. The data in this worksheet provides background information that is typically used to supplement a testing report.

VIEW DOWNLOAD

SEMI F47 Test Sheet

This Microsoft Excel file is used for lab testing of single-phase components against the SEMI F47 standard. This is a datasheet for compliance testing as there are a limited number of test durations required. The user fills in data fields that are in Red and the ride-through curve will be automatically plotted. Because many OEM's desire to test at both 50Hz and 60Hz, the datasheet accommodates this requirement.

DOWNLOAD

General Voltage Sag Test Sheet

This Microsoft Excel file is used for general testing of equipment and includes data sheets for single-phase and three-phase equipment tests. Three-phase equipment test datasheets are classified into the draft IEEE P1668 categories for Type I, II, and III. The user fills in data fields that are in Red and the ride-through curve will be automatically plotted.

Offline Resources at your fingertips

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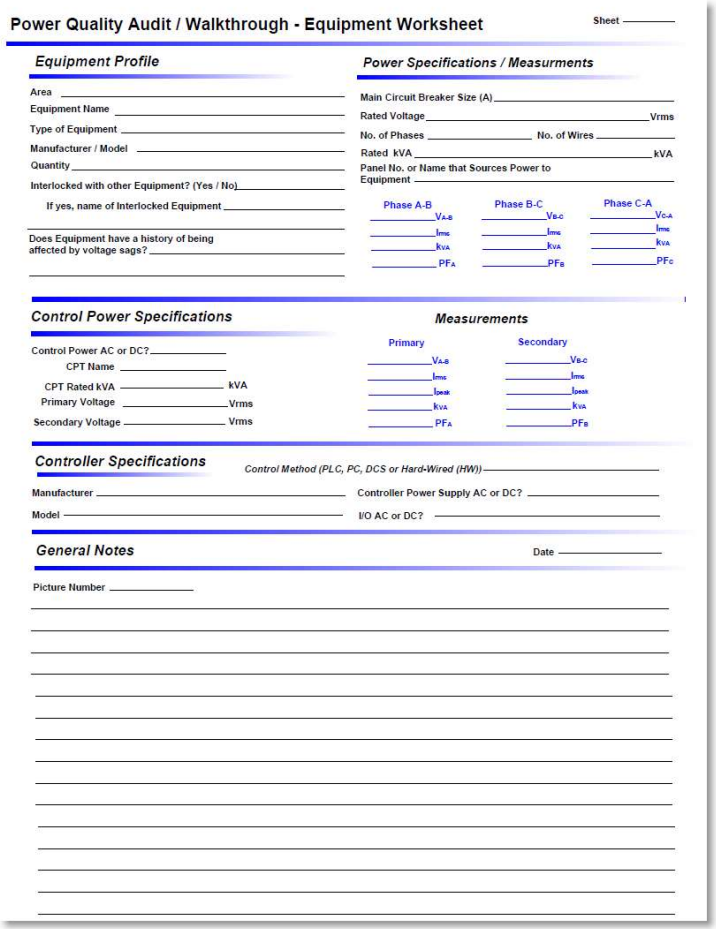
Tools Module:
Additional Resources - Worksheets

Worksheets
This page provides templates for recording Power Quality data.

- **PQ Assessment / Walkthrough - Equipment Worksheet**
- This worksheet is designed to facilitate an on-site assessment of customer equipment for power quality issues.
- The worksheet has sections for noting the equipment profile, power specifications and measurements, control power specifications and measurements, the specific controller information and I/O power source, and a notes section.
- This is one of the most frequently used worksheets by EPRI when conducting power quality work at customer sites.
- ***NOTE: Investigator Module has similar information that can be entered electronically now….***



Power Quality Audit / Walkthrough - Equipment Worksheet Sheet _____

Equipment Profile

Area _____
Equipment Name _____
Type of Equipment _____
Manufacturer / Model _____
Quantity _____
Interlocked with other Equipment? (Yes / No) _____
If yes, name of Interlocked Equipment _____
Does Equipment have a history of being affected by voltage sags? _____

Power Specifications / Measurments

Main Circuit Breaker Size (A) _____
Rated Voltage _____ Vrms
No. of Phases _____ No. of Wires _____
Rated kVA _____ kVA
Panel No. or Name that Sources Power to Equipment _____

Phase A-B	Phase B-C	Phase C-A
_____ V_{A-B}	_____ V_{B-C}	_____ V_{C-A}
_____ I_{rms}	_____ I_{rms}	_____ I_{rms}
_____ kVA	_____ kVA	_____ kVA
_____ PF_A	_____ PF_B	_____ PF_C

Control Power Specifications

Control Power AC or DC? _____
CPT Name _____
CPT Rated kVA _____ kVA
Primary Voltage _____ Vrms
Secondary Voltage _____ Vrms

Measurements

Primary	Secondary
_____ V_{A-B}	_____ V_{B-C}
_____ I_{rms}	_____ I_{rms}
_____ I_{peak}	_____ I_{peak}
_____ kVA	_____ kVA
_____ PF_A	_____ PF_B

Controller Specifications

Control Method (PLC, PC, DCS or Hard-Wired (HW)) _____
Manufacturer _____
Controller Power Supply AC or DC? _____
Model _____
I/O AC or DC? _____

General Notes Date _____

Picture Number _____

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Tools Module:
Additional Resources – Excel Worksheets

Worksheets
This page provides templates for recording Power Quality data.

Manufacturer:	Put Manufacturer Name Here
Series	Put Series Name Here
Part Number:	Put Part Number Here
Test Voltage	Put nominal test voltage here
Basic Spec	PS 24Vdc 20A
Date:	M/D/Y
Tested By:	PQ Engineer/Tech Name
Loading:	Load of unit
Notes:	Any specific test notes go here

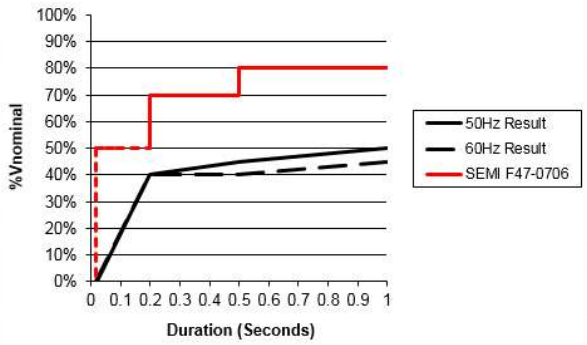
50Hz Testing

Cycles	Seconds	50Hz Result	SEMI F47-0706	Result (Pass/Fail)
50	1	50%	0.8	Pass
25	0.5	45%	0.7	Pass
10	0.2	40%	0.5	Pass
1	0.02	0%	0	Pass

60Hz Testing

Cycles	Seconds	60Hz Result	SEMI F47-0706	Result (Pass/Fail)
60	1	45%	0.8	Pass
30	0.5	40%	0.7	Pass
12	0.2	40%	0.5	Pass
1	0.017	0%	0	Pass

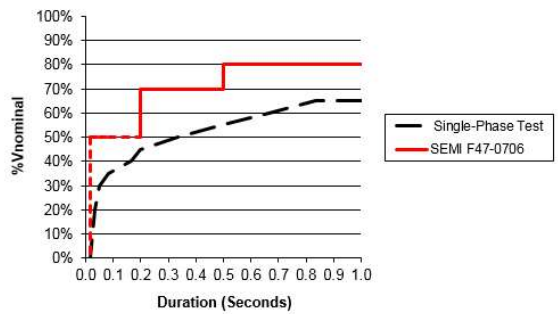
Note:SEMI F47-0706 0%Vnom, 1 Cycle Test Point is Recommended Only and Not Required.



Test Location:	Put Test Location here
Manufacturer:	Put Manufacturer Name Here
Series:	Put Series Name Here
Part Number:	Put Part Number Here
Rated Voltage:	Put rated voltage here
Test Voltage:	Put nominal test voltage here
Basic Spec:	Put basic spec (i.e. 24Vdc, 10A)
Date:	M/D/Y
Tested By:	PQ Engineer/Tech Name
Loading:	Load of unit
Frequency:	60 Hz (50/60)
Notes:	Any specific test notes go here

Data Table

Cycles	Seconds	Single-Phase Test	SEMI F47-0706	Outcome
60	1.000	65%	0.8	Ok/Shutdown
50	0.833	65%		Ok/Shutdown
40	0.667	60%		Ok/Shutdown
30	0.500	55%	0.7	Ok/Shutdown
20	0.333	50%		Ok/Shutdown
12	0.200	45%	0.5	Ok/Shutdown
10	0.167	40%		Ok/Shutdown
5	0.083	35%		Ok/Shutdown
3	0.050	30%		Ok/Shutdown
2	0.033	20%		Ok/Shutdown
1	0.017	0%	0	Ok/Shutdown



SEMI F47-0706 Requirement | IEEE P1668 Test Vectors | 1 Phase Voltage Sag Test Sheet

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Tools Module:
Additional Resources – Other Worksheets

Worksheets
This page provides templates for recording Power Quality data.

Equipment Specifications Worksheet

Equipment Owner	
Area	
Equipment Name	
Type of Equipment	
Manufacturer:	
Area of Focus	
Model	
S/N	
Date of Mfg	
Electrical Schematic Drawing Number	
Software Version	
Number of phases	
Number of wires	
Rated Voltage (Main Circuit Breaker)	
Rated Current (Main Circuit Breaker)	
Controls - Rated Voltage	
Controls - Rated Current	
Feeder Panel and Circuit Breaker Name	
Subsystem(s)	
Facility Support Equipment (Compressed Air, Chilled or DI Water,etc)	
Interlocked Process Equipment	

Notes

Steady State Measurements

Date:_____

Customer:_____Location:_____

Equipment or Subsystem Name:_____

Running State: _____

Measurement Parameters	Test Process State
Rated Voltage P-P	
Rated Voltage P-N	
Voltage (Va-n)	
Voltage (Vb-n)	
Voltage (Vc-n)	
Voltage (Va-b)	
Voltage (Vb-c)	
Voltage (Vc-a)	
Percentage of Error Based on Nominal and Rated	
Current (Ia)	
Current (Ib)	
Current (Ic)	
Power (W)a-n	
Power (W)b-n	
Power (W)c-n	
Volt Amps (VA)a-n	
Volt Amps (VA)b-n	
Volt Amps (VA)c-n	
Vthd (Phase A) %	
Vthd (Phase B) %	
Vthd (Phase C) %	
Ithd (Phase A) %	
Ithd (Phase B) %	
Ithd (Phase C) %	
Pfa	
Pfb	
Pfc	
Crest Factors (a)	
Crest Factors (b)	
Crest Factors (c)	
Hertz	

Equipment Response Worksheet

Power Disturbance History	*Yes*	*No*
Are PQ events recorded by facility or utility?		
Are equipment downtime logs available?		
If YES for both, Tolerance curves can be generated.		

What is the frequency	*Yes*	*No*
Random		
Specific Time of day (morning / afternoon / night)		
Season (Winter/Spring/Summer/Fall)		

Can shutdowns be related to? (check all that apply)	*Yes*	*No*
Starting or stopping of other loads in the same or adjacent facility?		
Do lights blink when shutdown occurs?		
Changes to the Electric Power System		
New loads or processes		

How does the equipment respond when power disturbances cause	*Yes*	*No*
Misoperation (Equipment stopped running)		
Blown fuses / circuit breakers		
Damaged equipment		
Reboot of PLCs or Computers		
Do programs have to be reloaded?		
Decreased Efficiency		
Equipment trips due to Overheating		
Are equipment fault codes available		
Adjustable Speed Drives Trip		
Data is lost or corrupted		
Does event cause more than one process to shutdown?		
Are ASD motors failing prematurely?		

What steps are taken to recover from a power quality related shutdown?	*Yes*	*No*
Replace power supplies		
Replace fuses		
Reset circuit breakers		

What is the Average delay time of a power quality related shutdown? hrs

What is the Average loss ($) for a single PQ related shutdown? $

Notes:

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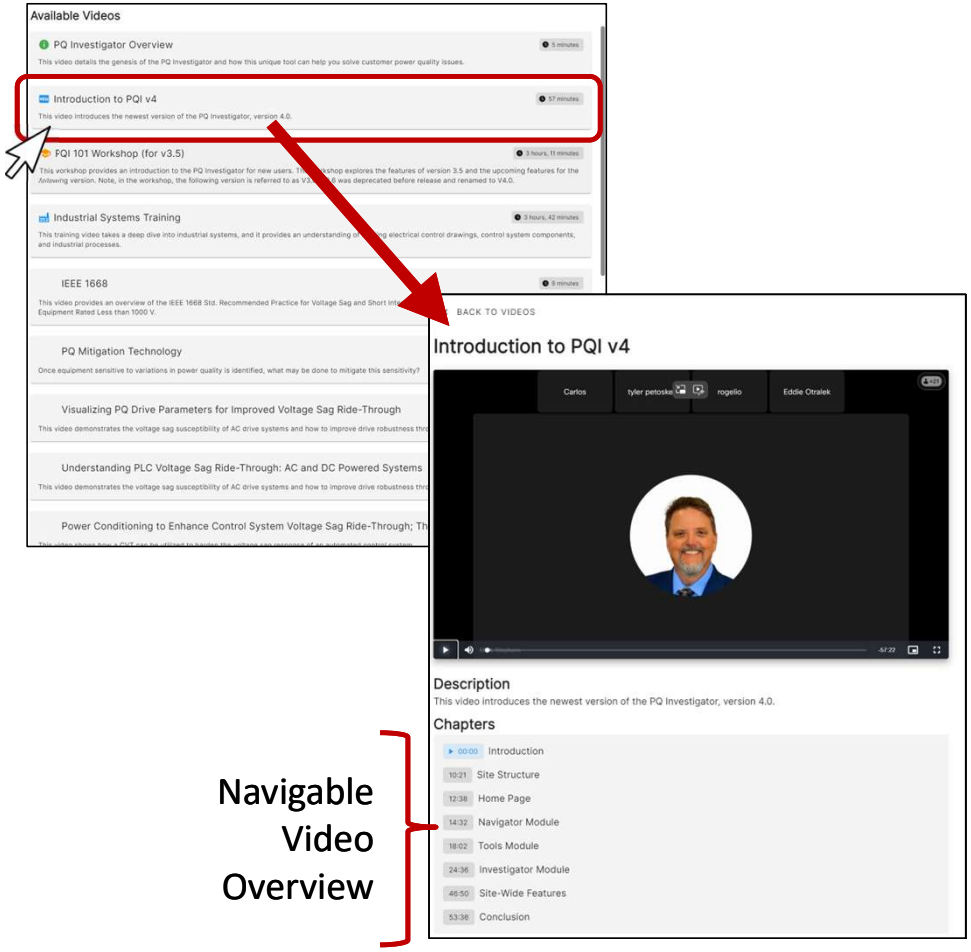
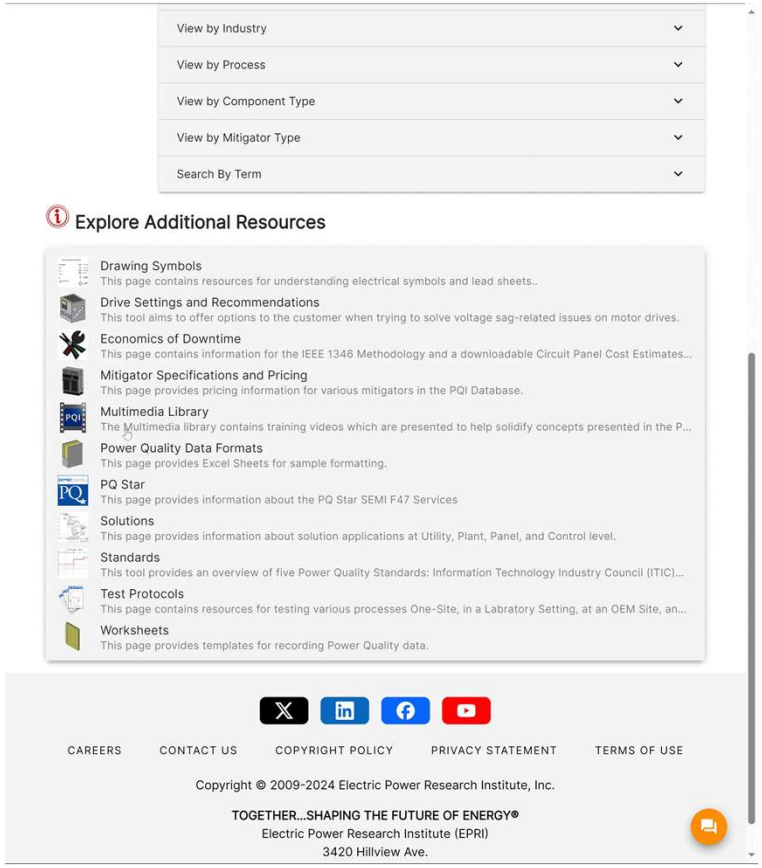
Additional Resources: Anatomy of Interactive Resources



Navigable Video Overview



Multimedia Library

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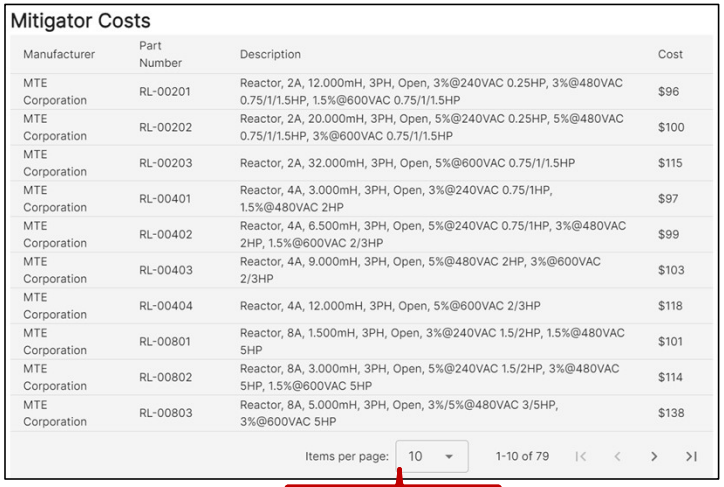
Additional Resources: Anatomy of Interactive Resources

Search Mitigator by Name or scroll the list

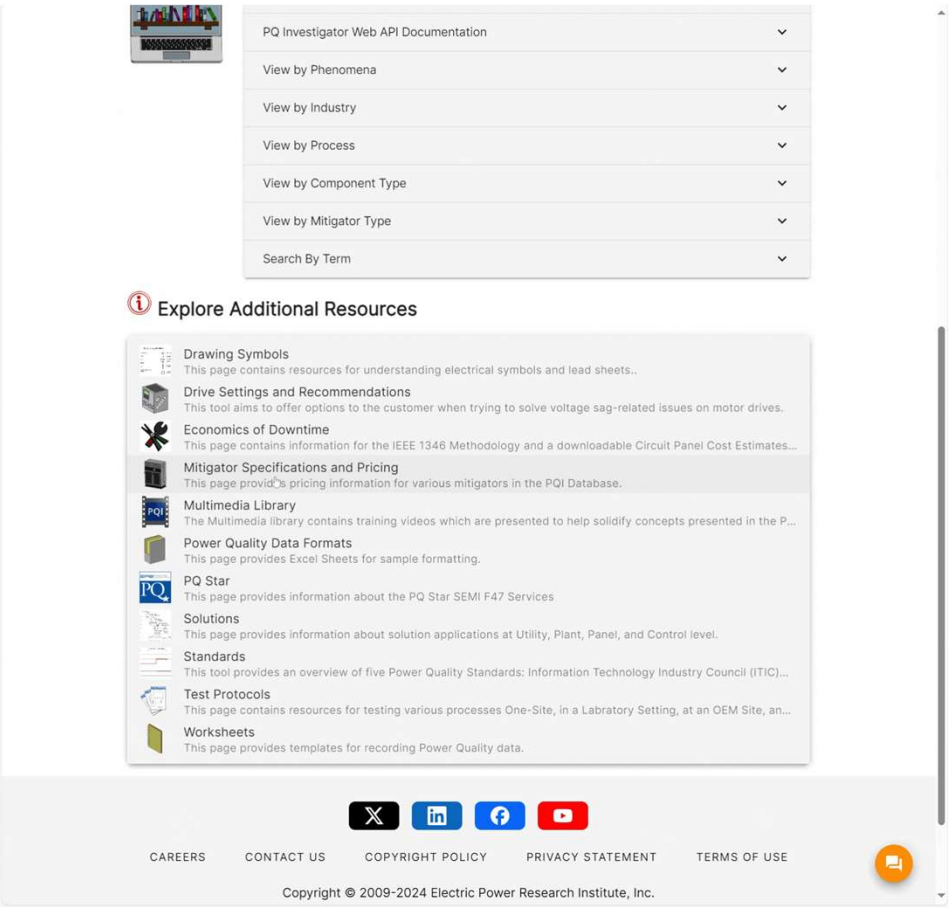


Mitigator Costs

Manufacturer	Part Number	Description	Cost
MTE Corporation	RL-00201	Reactor, 2A, 12.000mH, 3PH, Open, 3%@240VAC 0.25HP, 3%@480VAC 0.75/1/1.5HP, 1.5%@600VAC 0.75/1/1.5HP	$96
MTE Corporation	RL-00202	Reactor, 2A, 20.000mH, 3PH, Open, 5%@240VAC 0.25HP, 5%@480VAC 0.75/1/1.5HP, 3%@600VAC 0.75/1/1.5HP	$100
MTE Corporation	RL-00203	Reactor, 2A, 32.000mH, 3PH, Open, 5%@600VAC 0.75/1/1.5HP	$115
MTE Corporation	RL-00401	Reactor, 4A, 3.000mH, 3PH, Open, 3%@240VAC 0.75/1HP, 1.5%@480VAC 2HP	$97
MTE Corporation	RL-00402	Reactor, 4A, 6.500mH, 3PH, Open, 5%@240VAC 0.75/1HP, 3%@480VAC 2HP, 1.5%@600VAC 2/3HP	$99
MTE Corporation	RL-00403	Reactor, 4A, 9.000mH, 3PH, Open, 5%@480VAC 2HP, 3%@600VAC 2/3HP	$103
MTE Corporation	RL-00404	Reactor, 4A, 12.000mH, 3PH, Open, 5%@600VAC 2/3HP	$118
MTE Corporation	RL-00801	Reactor, 8A, 1.500mH, 3PH, Open, 3%@240VAC 1.5/2HP, 1.5%@480VAC 5HP	$101
MTE Corporation	RL-00802	Reactor, 8A, 3.000mH, 3PH, Open, 5%@240VAC 1.5/2HP, 3%@480VAC 5HP, 1.5%@600VAC 5HP	$114
MTE Corporation	RL-00803	Reactor, 8A, 5.000mH, 3PH, Open, 3%/5%@480VAC 3/5HP, 3%@600VAC 5HP	$138

Items per page: 10 1-10 of 79

Control how many costs per page



Mitigator Specifications and Pricing

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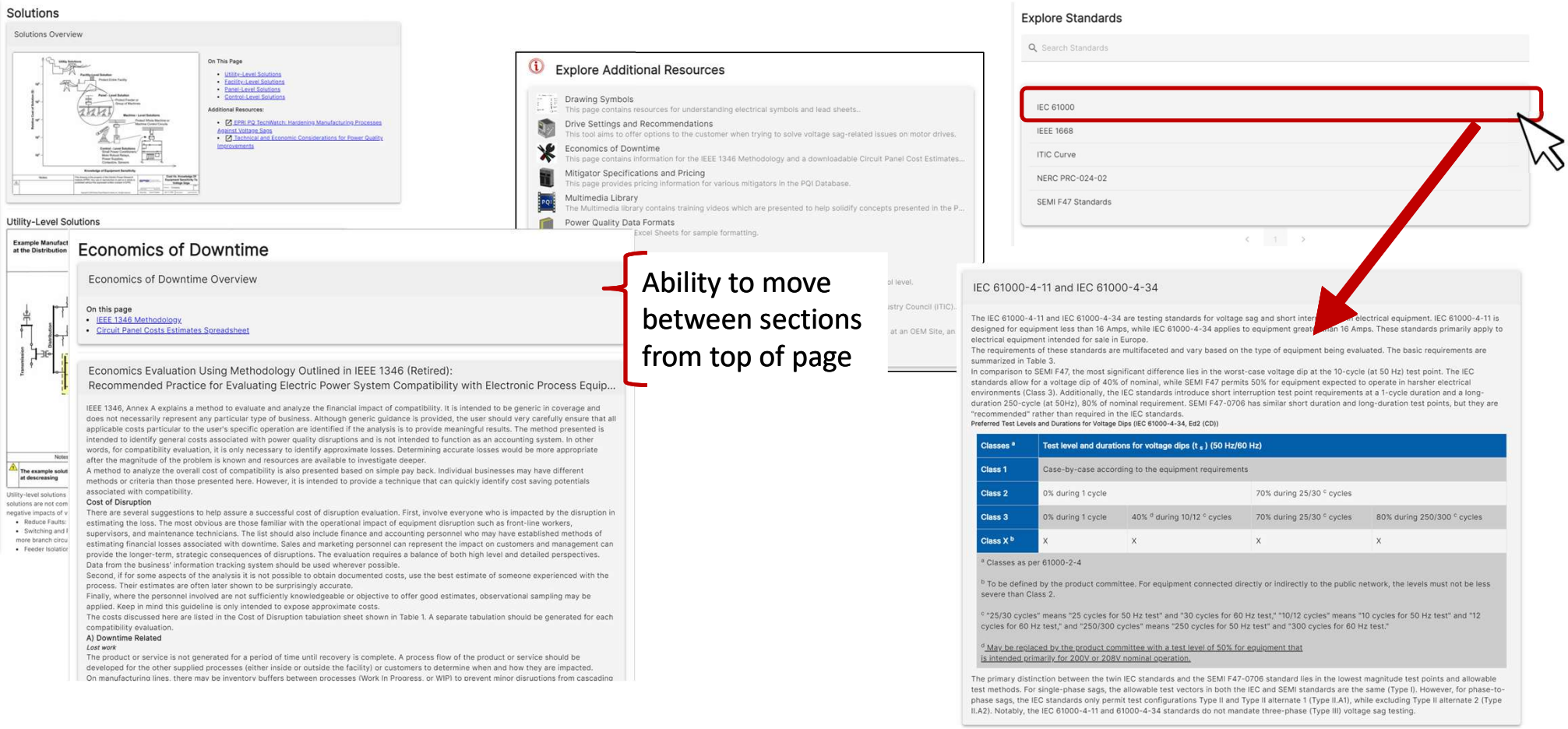
Additional Resources: Anatomy of Guides



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Tools Module: Additional Resources - Standards

TOOLS :: STANDARDS

- Specific Explanation of the ITIC, SEMI F47, IEC 61000-4-11 & 4-34, IEEE 1668, and NERC Standard PRC-024-2 standards are given in this section.

SEMI F47-0706

Although the ITIC curve was a useful benchmark, it is limited in scope as it addresses only information technology equipment. Furthermore, for typical voltage sags, the ITIC curve requires the equipment to operate only down to 70 percent of nominal. Given the great losses in the semiconductor manufacturing process, a more stringent requirement was developed. A task force considered power quality information from 15 transmission fed semiconductor plant sites, representing 1076 events and 30.5 years of monitoring data. The analysis indicated that equipment that was compliant to the proposed curve would likely trip less than 3 times per year.

The resulting standard is known as the SEMI F47 standard. SEMI stands for Semiconductor Equipment and Materials International. "F47" came from the fact that this standard was the 47th facilities standard written by the organization to govern the operation of equipment in semiconductor factories. This standard was first published in 1999 and revised in 2000 and 2006. The standard defines the voltage sag immunity requirements for equipment that is used in semiconductor factories. Unlike the ITIC curve which was written for single-phase IT type loads, the SEMI F47 standard is relevant for single, two and three phase manufacturing equipment. Such equipment includes common electrical devices such a motor drives, PLCs, relays, power supplies, and instrumentation. In addition, there are unique devices that are included in this industry such as specialized vacuum pumps, turbo pumps, RF generators, and plasma generator power supplies. The test point requirements of the standard are shown in the table below and the following chart.

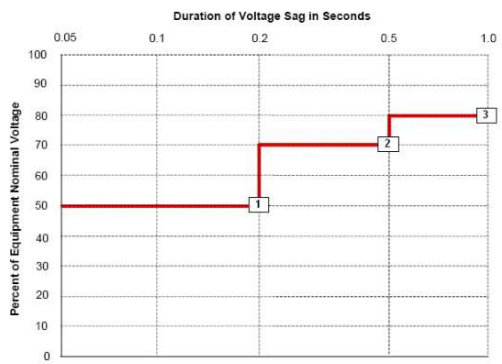
For each of the test points, the equipment operation is not to suffer an interrupt in function and must continue operation without manual intervention.

Required SEMI F47-0706 Test Points (Single and Two-Phase Voltage Sags Only)

Minimum Test Point No.	Sag Depth	Duration in Seconds	Duration at 50Hz	Duration at 60Hz
1	50%	0.2 Seconds	10 cycles	12 cycles
2	70%	0.5 Second	25 cycles	30 cycles
3	80%	1.0 Second	50 cycles	60 cycles

The "Sag depth" in Table 1 is expressed in percent of remaining nominal voltage. For example, during a 70% sag on a 480 volt nominal system, the voltage is reduced during the sag to 336 volts (not 144 volts).

Required Voltage Sag Immunity Sag depth and Minimum Test Points from SEMI F47-0706

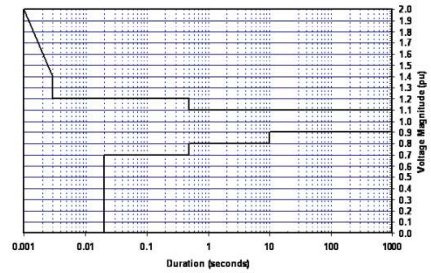


If the equipment has a neutral conductor, then single-phase testing is required in addition to phase-to-phase testing. For single-phase testing, voltage sags are created on one phase at a time for the magnitudes and durations shown in the standard. Such testing is designated "Type I" as it is related to single-phase testing. Example vectors for Type I testing are shown below.

INFORMATION TECHNOLOGY INDUSTRY COUNCIL (ITIC) CURVE

The first industry recognized standard that set boundaries for equipment performance related to voltage sags was the original CBEMA (Computer & Business Equipment Manufacturer's Association) curve. This standard set both an upper and lower voltage tolerance requirement for single-phase computer based equipment fed from voltages that range from 120Vac to 240Vac. Later updated in 1996, and renamed the ITIC (Information Technology Industry Council) curve, the standard is focused on single-phase computer equipment. With respect to voltage sags, the lower curve is relevant.

The ITIC Curve



IEC 61000-4/11 & 61000-4-34

The IEC 61000-4-11 and IEC 61000-4-34 are voltage sag and short interruption testing standards for equipment less than and greater than 16 Amps, respectively. These standards primarily apply to electrical equipment that is to be sold in Europe. The requirements of the standard are multifaceted depending on what type of equipment is to be evaluated. The basic requirements of the standard are shown in Table 3. In contrast to SEMI F47, the worst case voltage dip at the 10 cycle (at 50 Hz) test point is 40 % of nominal versus 50% of nominal for SEMI F47 for equipment expected to operate in harsher electrical climates (Class 3). Furthermore, there are short interruption test point requirements at 1 cycle duration and a long duration 250 cycle (at 50Hz), 80 % of nominal requirement. SEMI F47-0706 has similar short duration and long duration test points, but they are "recommended" versus required for the IEC standards.

Preferred Test Levels and Durations for Voltage Dips (IEC 61000-4-34, Ed2 (CD))

Classes[a]	Test level and durations for voltage dips (t_d) (50 Hz/60 Hz)			
Class 1	Case-by-case according to the equipment requirements			
Class 2	0 % during 1 cycle		70 % during 25/30[c] cycles	
Class 3	0 % during 1 cycle	40 %[c] during 10/12[c] cycles	70 % during 25/30[c] cycles	80 % during 250/300[c] cycles
Class X[b]	X	X	X	X

[a] Classes as per 61000-2-4

[b] To be defined by product committee. For equipment connected directly or indirectly to public network, the levels must not be less severe than class 2.

[c] "25/30 cycles" means "25 cycles for 50 Hz test" and "30 cycles for 60 Hz test", "10/12 cycles" means "10 cycles for 50 Hz test" and "12 cycles for 60 Hz test" and "250/300 cycles" means "250 cycles for 50 Hz test" and "300 cycles for 60 Hz test".

[d] May be replaced by product committee with a test level of 50% for equipment that is intended primarily for 200V or 208V nominal operation.

The key difference between the twin IEC standards and the SEMI F47-0706 standard include the lowest magnitude test points as well as the allowable test methods. For single-phase sags, the allowable test vectors for the IEC and SEMI standards are the same as Type I). However, for phase-to-phase sags, these two IEC standards only allow test configurations Type II and Type II alternate 1 (Type II A1) while not allowing Type II alternate 2 (Type II A2). The IEC 61000-4/11 and 61000-4-34 standards do not require three phase (Type III) voltage sag testing.

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NERC PRC-024-02 LVRT Curve & Standard Info

TOOLS .: STANDARDS

Tools…Standards

NERC Standard PRC-024-2: Generator Frequency and Voltage Protective Relay Settings

General

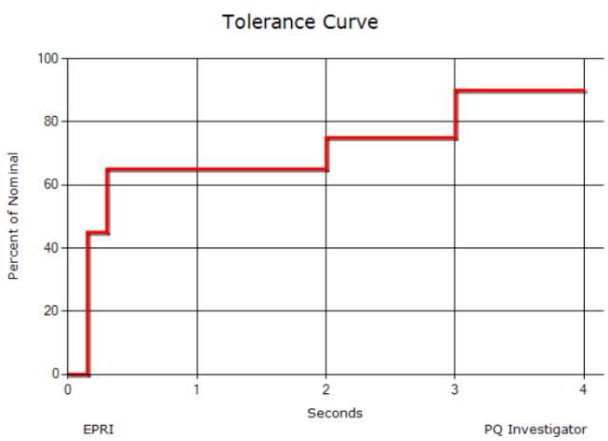
This PRC-024-02 standard assists NERC Registered Entities in developing a common understanding of the practices and processes surrounding the evaluation of voltage protective relay settings associated with Generator Owners. These parameters include over and under frequency trip requirements and high and low voltage trip requirements.

PRC-024-02 Ride-Through Duration Requirements

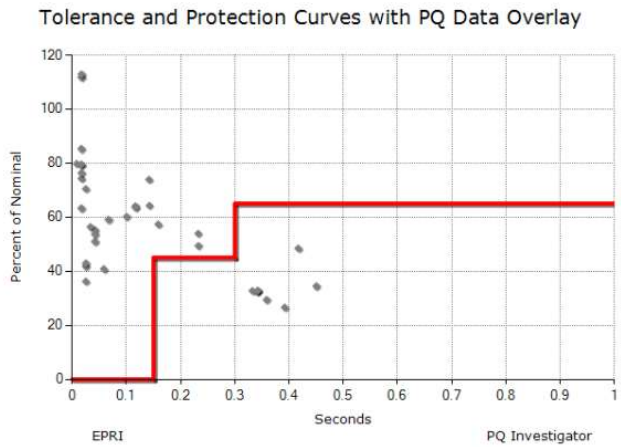
High Voltage Ride-Through Duration		Low Voltage Ride-Through Duration	
Voltage (pu)	Time (sec)	Voltage (pu)	Time (sec)
≥1.200	Instantaneous Trip	<0.45	0.15
≥1.175	0.20	<0.65	0.30
≥1.15	0.50	<0.75	2.00
≥1.10	1.00	<0.90	3.00

The PQI includes the Low Voltage Ride-Through Curve Duration Settings for the standard as shown below.

NERC,PRC-024-02,Low Voltage Ride Through Curve,January 19 2018



Curves Module



NERC,PRC-024-02,Low Voltage Ride Through Curve,January 19 2018,60Hz

PQ Data, Turner308_Bus1 (1/2/2017 7:10:37 AM - 1/5/2018 5:11:26 AM)

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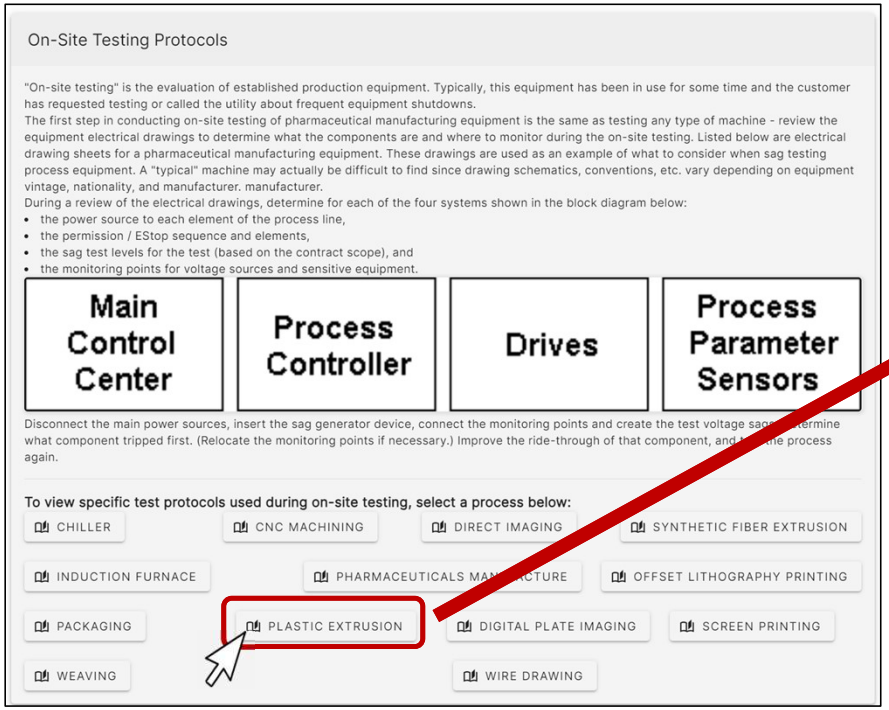
Tools Module: Additional Resources – Test Protocols

Example On-Site, Lab, OEM Site, and Sample In-Place Test Protocols are provided for many different types of equipment.



On-Site Testing Protocols

"On-site testing" is the evaluation of established production equipment. Typically, this equipment has been in use for some time and the customer has requested testing or called the utility about frequent equipment shutdowns.
The first step in conducting on-site testing of pharmaceutical manufacturing equipment is the same as testing any type of machine - review the equipment electrical drawings to determine what the components are and where to monitor during the on-site testing. Listed below are electrical drawing sheets for a pharmaceutical manufacturing equipment. These drawings are used as an example of what to consider when sag testing process equipment. A "typical" machine may actually be difficult to find since drawing schematics, conventions, etc. vary depending on equipment vintage, nationality, and manufacturer. manufacturer.
During a review of the electrical drawings, determine for each of the four systems shown in the block diagram below:

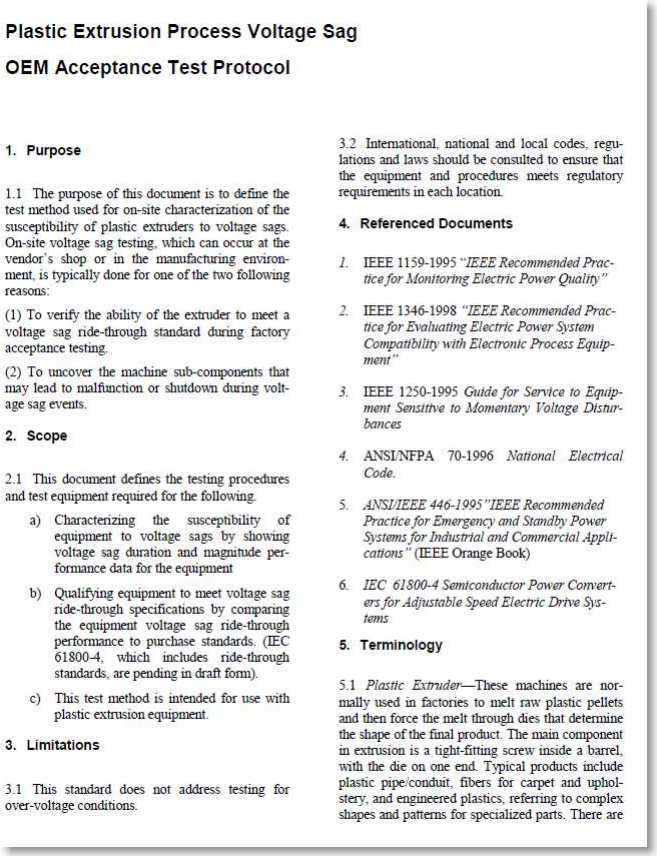
- the power source to each element of the process line,
- the permission / EStop sequence and elements,
- the sag test levels for the test (based on the contract scope), and
- the monitoring points for voltage sources and sensitive equipment.

Main Control Center | Process Controller | Drives | Process Parameter Sensors

Disconnect the main power sources, insert the sag generator device, connect the monitoring points and create the test voltage sag. Determine what component tripped first. (Relocate the monitoring points if necessary.) Improve the ride-through of that component, and test the process again.

To view specific test protocols used during on-site testing, select a process below:

CHILLER | CNC MACHINING | DIRECT IMAGING | SYNTHETIC FIBER EXTRUSION
INDUCTION FURNACE | PHARMACEUTICALS MANUFACTURE | OFFSET LITHOGRAPHY PRINTING
PACKAGING | PLASTIC EXTRUSION | DIGITAL PLATE IMAGING | SCREEN PRINTING
WEAVING | WIRE DRAWING



Plastic Extrusion Process Voltage Sag

OEM Acceptance Test Protocol

1. Purpose

1.1 The purpose of this document is to define the test method used for on-site characterization of the susceptibility of plastic extruders to voltage sags. On-site voltage sag testing, which can occur at the vendor's shop or in the manufacturing environment, is typically done for one of the two following reasons:

(1) To verify the ability of the extruder to meet a voltage sag ride-through standard during factory acceptance testing.

(2) To uncover the machine sub-components that may lead to malfunction or shutdown during voltage sag events.

2. Scope

2.1 This document defines the testing procedures and test equipment required for the following.

a) Characterizing the susceptibility of equipment to voltage sags by showing voltage sag duration and magnitude performance data for the equipment

b) Qualifying equipment to meet voltage sag ride-through specifications by comparing the equipment voltage sag ride-through performance to purchase standards. (IEC 61800-4, which includes ride-through standards, are pending in draft form).

c) This test method is intended for use with plastic extrusion equipment.

3. Limitations

3.1 This standard does not address testing for over-voltage conditions.

3.2 International, national and local codes, regulations and laws should be consulted to ensure that the equipment and procedures meets regulatory requirements in each location.

4. Referenced Documents

1. IEEE 1159-1995 *"IEEE Recommended Practice for Monitoring Electric Power Quality"*
2. IEEE 1346-1998 *"IEEE Recommended Practice for Evaluating Electric Power System Compatibility with Electronic Process Equipment"*
3. IEEE 1250-1995 *Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances*
4. ANSI/NFPA 70-1996 *National Electrical Code.*
5. *ANSI/IEEE 446-1995 "IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications"* (IEEE Orange Book)
6. *IEC 61800-4 Semiconductor Power Converters for Adjustable Speed Electric Drive Systems*

5. Terminology

5.1 *Plastic Extruder*—These machines are normally used in factories to melt raw plastic pellets and then force the melt through dies that determine the shape of the final product. The main component in extrusion is a tight-fitting screw inside a barrel, with the die on one end. Typical products include plastic pipe/conduit, fibers for carpet and upholstery, and engineered plastics, referring to complex shapes and patterns for specialized parts. There are

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