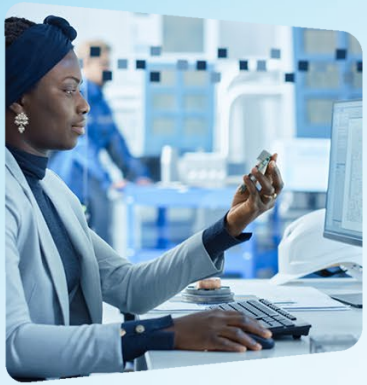




IEEE IAS Atlanta Chapter Meeting

03/20/23

IEEE
Advancing Technology for Humanity

Agenda

- Members Open Forum
- Main Presentation
- Q&A
- Next Meeting Announcement

Members Open Forum

In an Orderly Fashion, Please Unmute Yourself or Request the Microphone

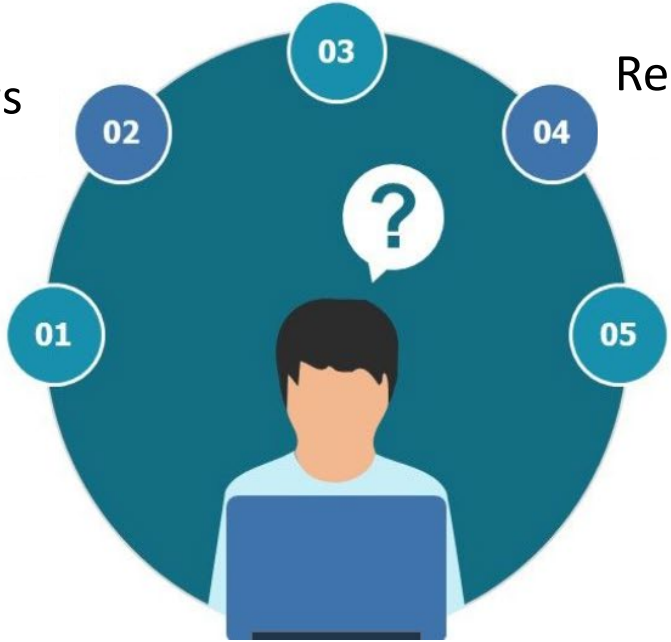
Outreach Opportunities

Job Openings

Recommended Topics

Related Announcements

Asks



Collecting Data for Power Systems Models & Managing Assumptions

Presenter: Tryton Bower, P.E. - Power Distribution Group Team Lead – Mangan, Inc.

- Bachelor of Science, Electrical Engineering, University of California, Santa Cruz
- Based in Alpharetta, GA
- Joined Mangan, Inc. in 2009
- 13 years of project experience in electrical distribution systems for petrochemical, upstream, and midstream facilities
- Author of multiple Petroleum and Chemical Industry Committee (PCIC) papers
- Registered P.E. in several states

tbower@manganinc.com

Assumptions in an Arc Flash Model

- IEEE 1584.1-2013, Section 5.2:
  - "If data is not available or accessible for protective devices such as protective relays, current transformer's (CTs), circuit breakers, and fuses, but reasonable assumptions can be made as to the devices type or characteristics, these assumptions may be used."

Model Data Collection Process

- Logistics & Outage Coordination
- PPE Management
- Utility Coordination & Data Evaluation
- Practical Framework of Assumptions

Realities of Logistics & Data Collection

- Plan Ahead!

Realities of Logistics & Data Collection

- De-energized vs. Energized Field Verification

Realities of Logistics & Data Collection

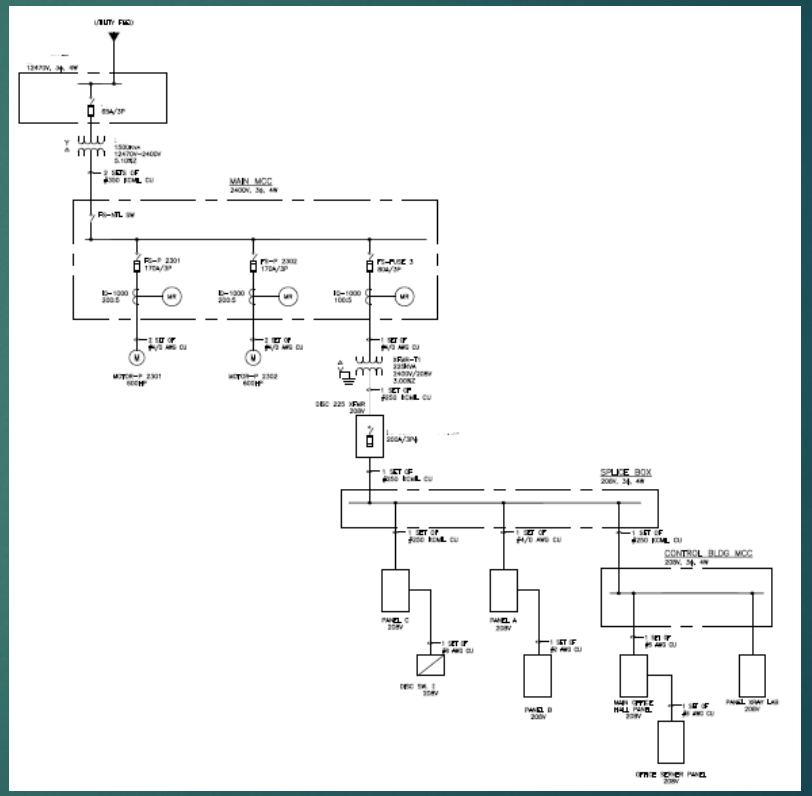
- Coordinate with Stakeholders

Realities of Logistics & Data Collection

- Schedule Utility Outages

Realities of Logistics & Data Collection

- Obtain documentation

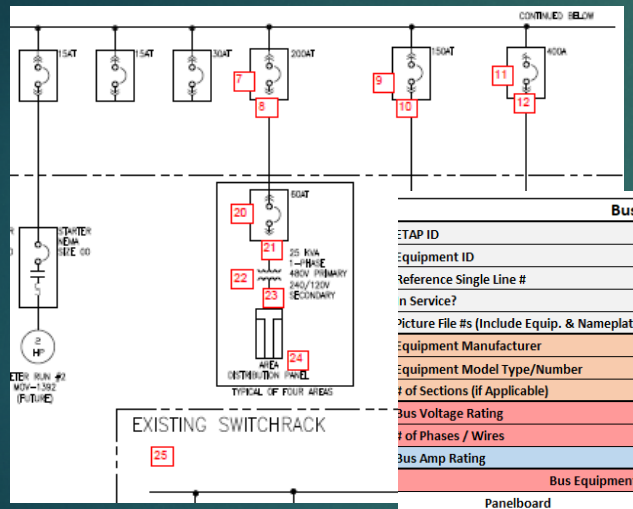


Realities of Logistics & Data Collection

- Execution Plans

Realities of Logistics & Data Collection

- Data Collection Forms



Bus Data	
ETAP ID	
Equipment ID	OUTDOOR MCC
Reference Single Line #	3
In Service?	
Picture File #s (Include Equip. & Nameplate)	
Equipment Manufacturer	
Equipment Model Type/Number	
# of Sections (if Applicable)	
Bus Voltage Rating	
# of Phases / Wires	
Bus Amp Rating	
Bus Equipment Type (Circle One)	
Panelboard	MCC
Switchgear	Open Air
Switchrack	Cable bus
Switchboard	Cable J-Box
Other	
Bus Equipment Dimensions 1 (As Required)	
Main PD Isolated?	
Electrode Configurations	
Electrode Gap (in)	
Height (in)	
Width (in)	
Depth (in) (only if LV & <8")	

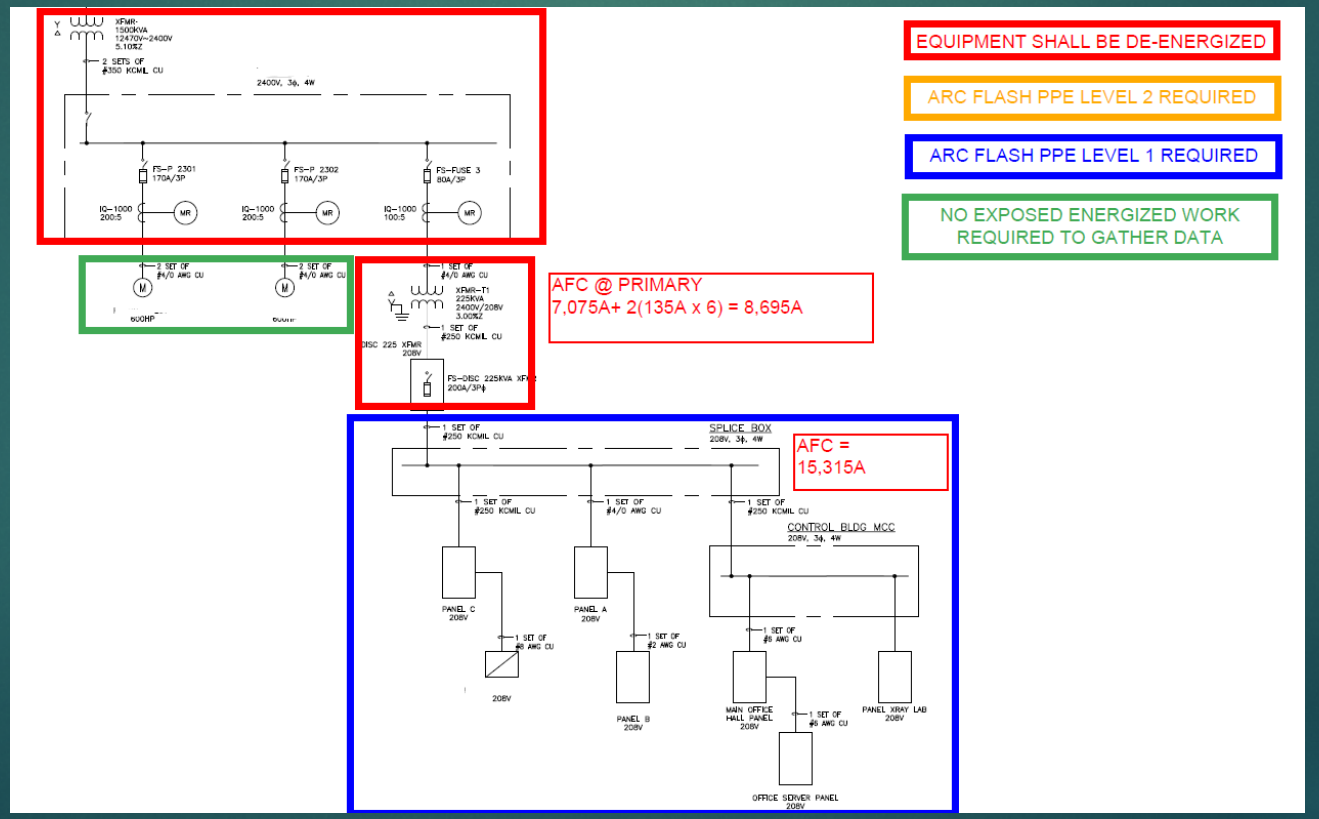
HVCB	
ETAP ID	
Equipment ID	OUTDOOR MCC MAIN BREAKER
Reference Single Line #	4
In Service?	
NO/NC?	
Picture File #s (Include Equip., Nameplate, 86)	
Manufacturer	
Model #	
Voltage Rating	
Amp Rating	
Interrupting Rating	
Opening Time Rating	
Tripped Via Lockout Relay?	
Lockout Relay Manufacturer	
Lockout Relay Model #	

LVCB	
ETAP ID	
Equipment ID	STATION DIST PNL BKR
Reference Single Line #	5
In Service?	
NO/NC?	
Picture File #s (Include Equip. & Nameplate)	
Manufacturer	
Model #	
Voltage Rating	
Frame Rating	
Amp Rating	
Interrupting Rating	
LVCB Trip Unit/MCP	
Device Type	
Manufacturer	
Model #	
Picture? (All dials & settings)	
Trip Unit Ratings	
Sensor Plug Rating	
Long Time Pickup	
Long Time Delay	
Short Time Delay	
Short Time Pickup	
Short Time I^2t IN/OUT	

STATION DIST PNL CABLE	Cable	6
AREA DIST PNL BKR	LVCB	7
AREA DIST PNL CABLE	Cable	8
SWRK BKR1	LVCB	9
SWRK BKR1 CABLE	Cable	10
[illegible]	LVCB	11
[illegible]	Cable	12
[illegible]	LVCB	13
Contactor		14
Overload		15
Cable		16
Transformer		17
Cable		18
Bus		19

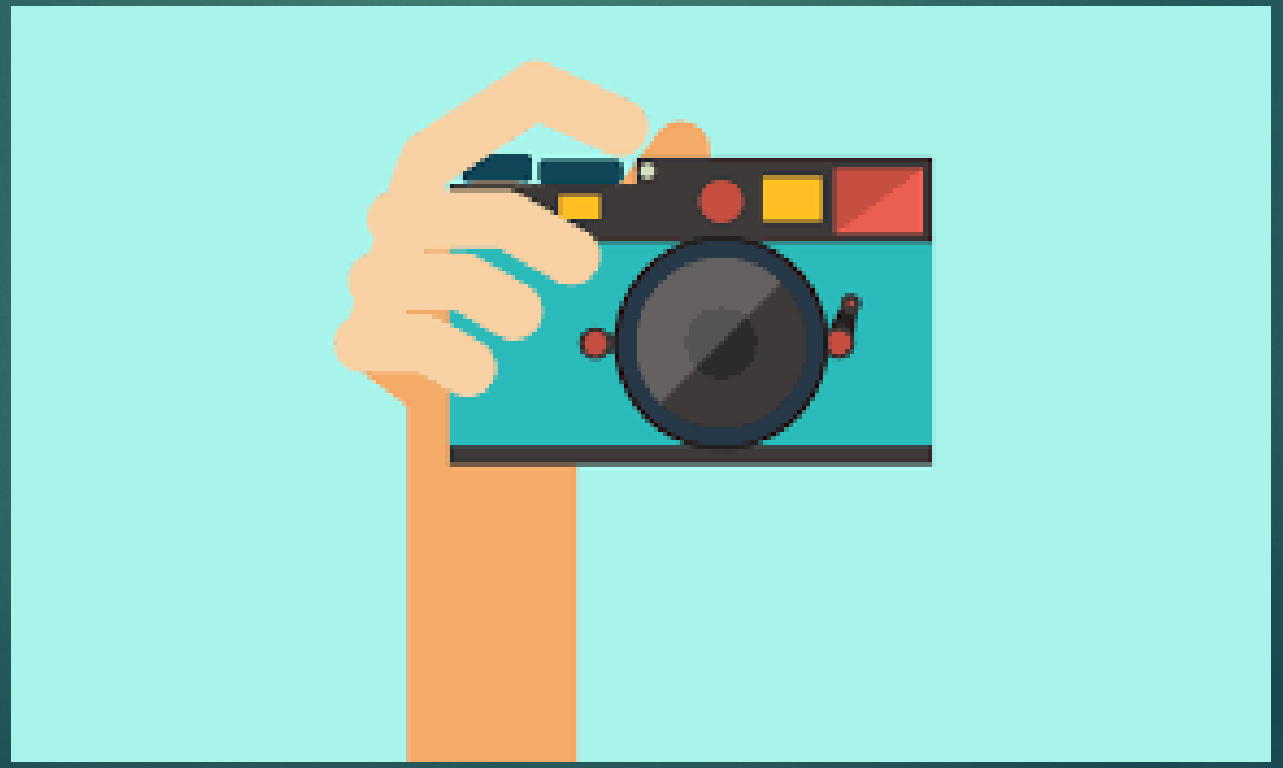
PPE Management

- PPE Selection (Energized Verification)



Data Collection Methods

- Take Pictures, be organized



Data Collection Methods

- Experienced Engineer

Utility Coordination

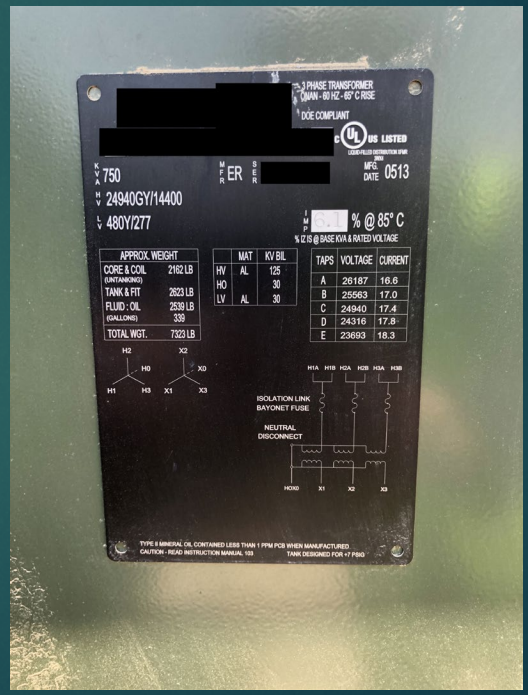
- Obtaining Utility Data

Utility Coordination

- Provide Utilities with Information

Utility Coordination

- Not Just Available Fault Current Data



Utility Coordination

- Verify Validity of Short Circuit Data

Utility Coordination

- Case Study: Utility Available Fault Current

Framework for Assumptions

Framework for Assumptions

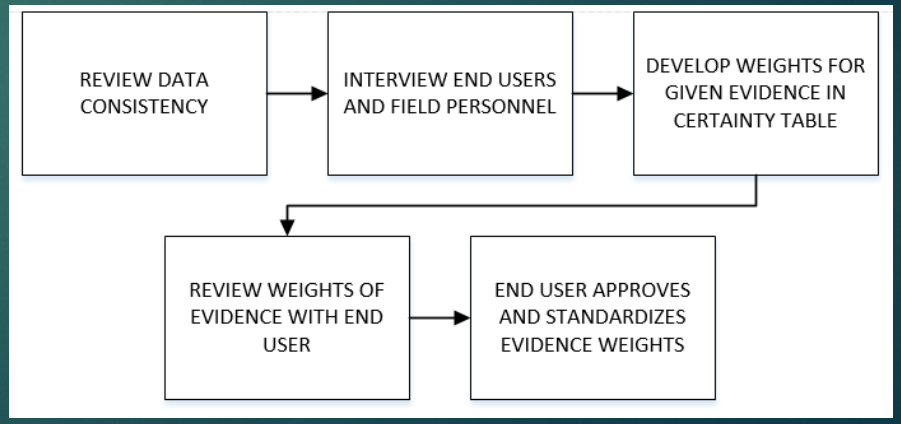
- How do we make assumptions?

Framework for Assumptions

- What evidence do we look for and use?
  - Maintenance Documentation
  - Surrounding Equipment
  - Field Feedback
  - Existing Documentation
  - Codes and Standards

Framework for Assumptions

- How much can we trust the evidence? Who decides how much we can trust it?
  - Apply weights to the type of evidence.
    - Maintenance Documentation (Wmd)
    - Surrounding Equipment (Wse)
    - Field Feedback (Wff)
    - Existing Documentation (Wed)
    - Codes and Standards (Wcs)



Framework for Assumptions

- Example
  - Maintenance Documentation (Wmd)

Routine Notes:

TESTED AS FOUND SETTINGS. NO COORDINATION STUDY AVAILABLE.

Relay Settings Used for Testing:

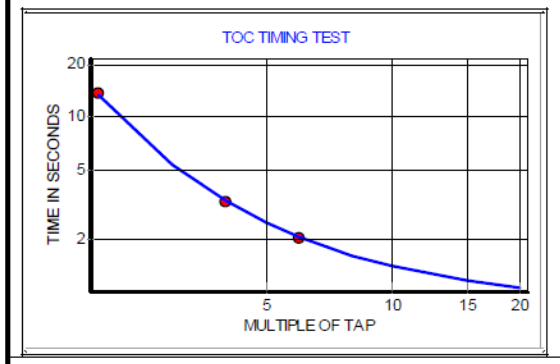
TAP=	10	TIME_DIAL=	6	RESET_TIME=	30
INST=	55	SEAL_IN=	0.2		

Relay Test Results for: TOC UNIT PICKUP TEST

DROPOUT	PICKUP	IDEAL	RANGE	OK?
10.350	10.400	10.000	9.500 TO 10.500	PASS

Relay Test Results for: TOC TIMING TEST

MULTIPLE	VALUE	TIME(CY)	TIME(SEC)	IDEAL	%ERROR	OK?
2.00	20.000	818.81	13.647	13.211	3.30	PASS
4.00	40.000	197.20	3.287	3.332	-1.36	PASS
6.00	60.000	122.24	2.037	2.058	-1.01	PASS



Relay Test Results for: INST UNIT TEST

Framework for Assumptions

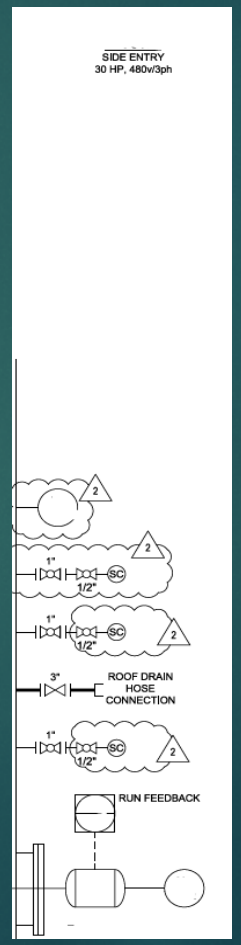
- Example
  - Surrounding Equipment (Wse)

Framework for Assumptions

- Example
  - Field Feedback (Wff)

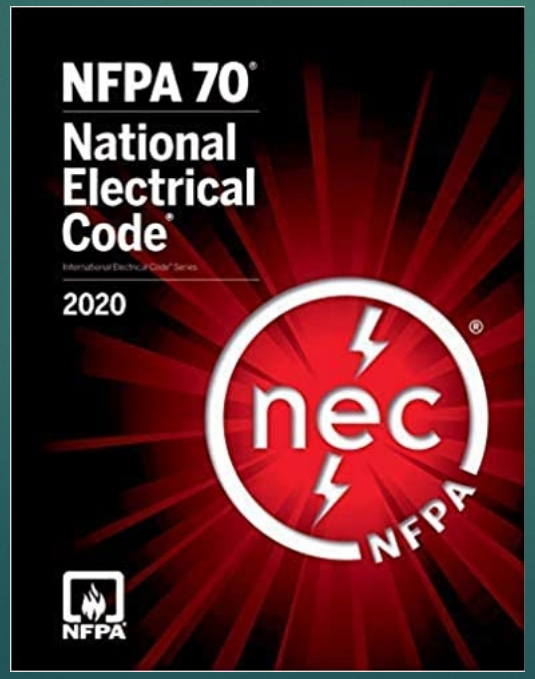
Framework for Assumptions

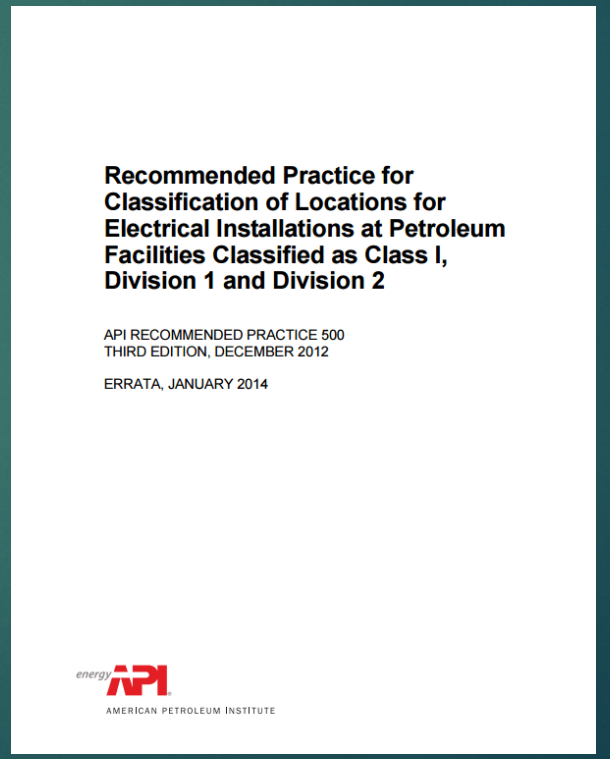
- Example
  - Existing Documentation (Wed)



Framework for Assumptions

- Example
  - Codes and Standards (Wcs)





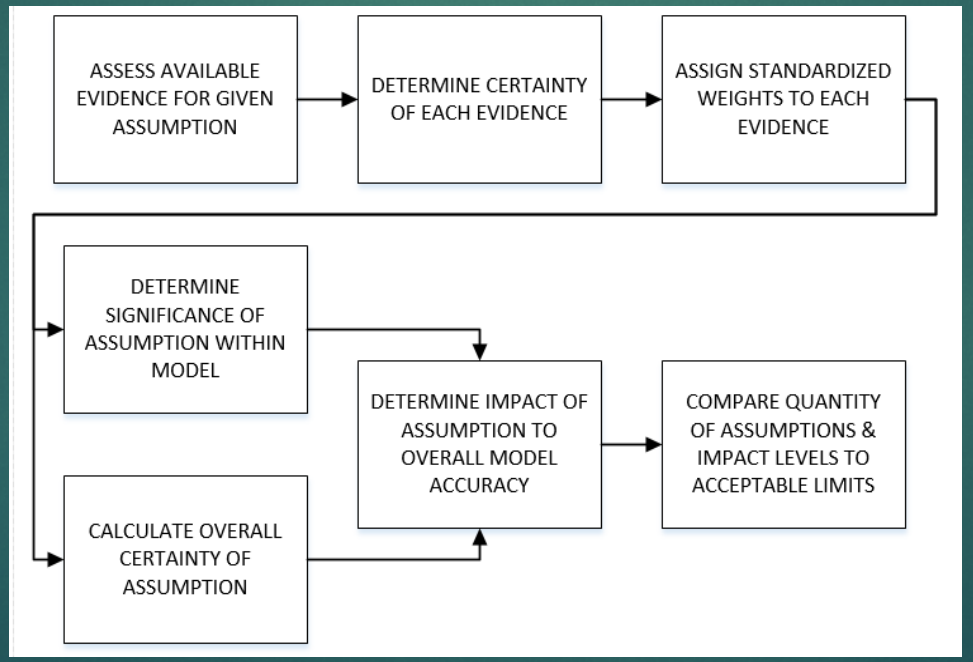
Framework for Assumptions

TABLE I
EXAMPLE WEIGHT VALUES FOR CERTAINTY

Evidence Category	Assigned Weight
Maintenance Documentation (W_{md})	0.40
Surrounding Equipment (W_{se})	0.40
Field Feedback (W_{ff})	0.10
Existing Documentation (W_{ed})	0.20
Codes and Standards (W_{cs})	0.10

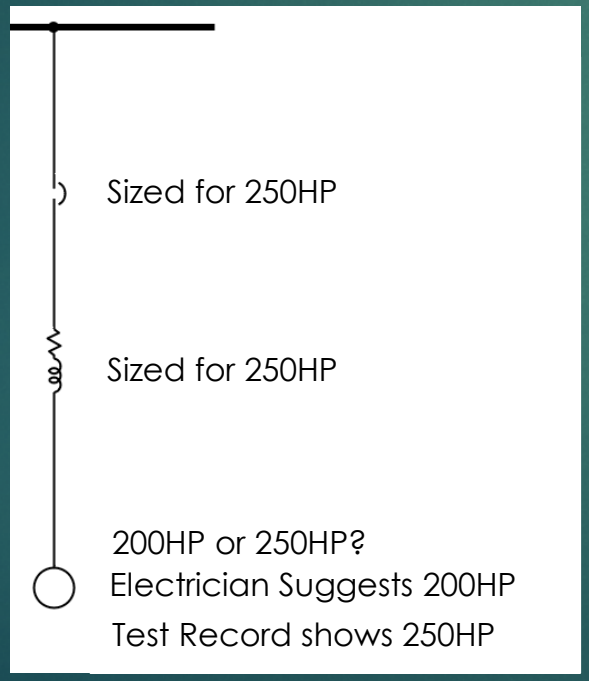
Framework for Assumptions

- So what was the point in that exercise?



Framework for Assumptions

- Missing Motor Data



Framework for Assumptions

$$C = \text{Min}\left\{C_{max}, \begin{pmatrix} W_{md}C_{md} + W_{se}C_{se} + W_{ff}C_{ff} \\ + W_{ed}C_{ed} + W_{cs}C_{cs} \end{pmatrix}\right\}$$

C overall certainty of an assumption
C_{max} maximum allowable assumption certainty
C_{md} certainty of maintenance documentation evidence
C_{se} certainty of surrounding equipment evidence
C_{ff} certainty of surrounding field feedback evidence
C_{ed} certainty of surrounding existing documentation evidence
C_{cs} certainty of codes and standards evidence

TABLE III
EXAMPLE A CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	?
Surrounding Equipment	0.40	?
Field Feedback	0.10	?
Existing Documentation	0.20	?
Codes & Standards	0.10	?
Total Calculated Certainty Using (1)	?	

Framework for Assumptions

- C_{md} certainty of maintenance documentation evidence
- C_{ff} certainty of field feedback evidence
- C_{ed} certainty of existing documentation evidence
- C_{cs} certainty of codes and standards evidence

- If evidence supports the assumption: 1.0
- If evidence contradicts the assumption: 0
- If evidence doesn't exist: 0.5

Framework for Assumptions

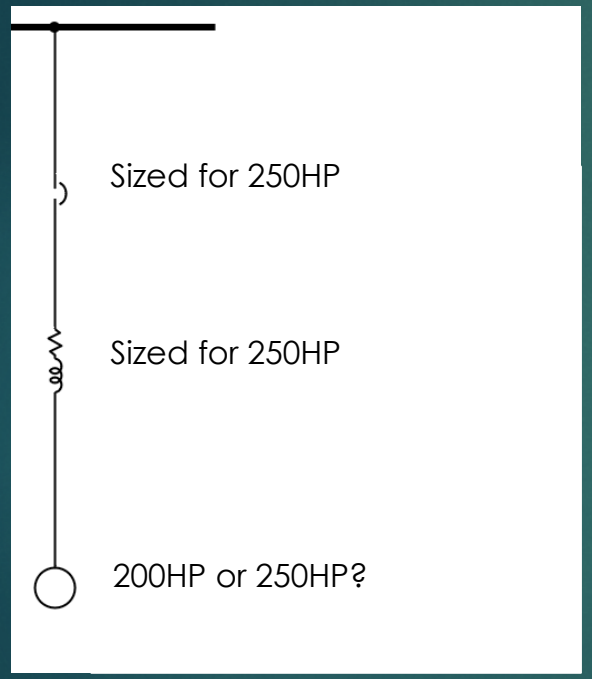


TABLE III
EXAMPLE A CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	1.0
Surrounding Equipment	0.40	?
Field Feedback	0.10	0
Existing Documentation	0.20	0
Codes & Standards	0.10	1.0
Total Calculated Certainty Using (1)	?	

Framework for Assumptions

- C_{se}: certainty of surrounding equipment evidence

TABLE II
CERTAINTY BASED ON SURROUNDING EQUIPMENT (C_{se})

Pieces of Equipment	Assigned Certainty (C_{se})	
	Supporting Evidence	Contradictory Evidence
1	0.4	-0.2
2	0.8	-0.4
3 or more	1.0	-0.5

3 pieces of equipment indicate 250HP
$Cse = 1.0$

If *cable indicated* $200HP$
Cse would equal
$(0.8 - 0.2 = 0.6)$

Framework for Assumptions

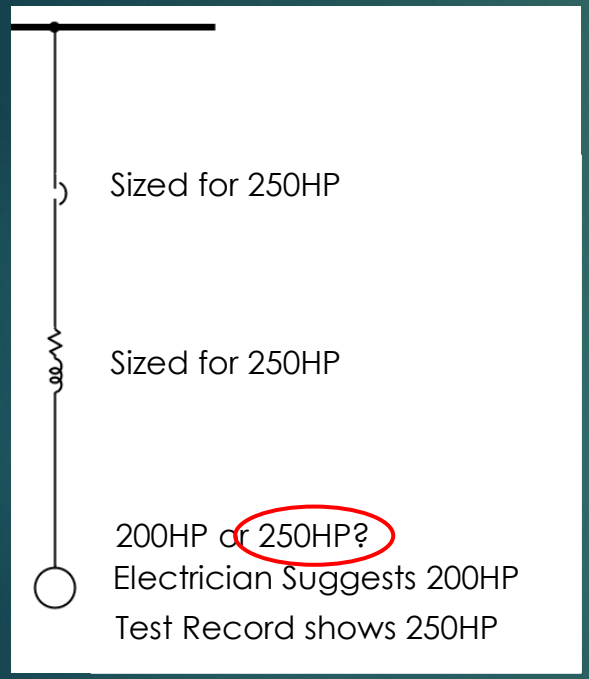
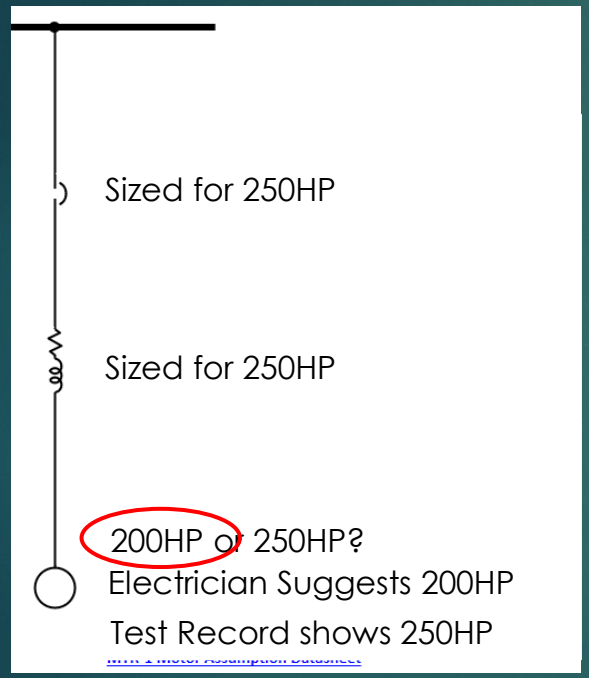


TABLE III
EXAMPLE A CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	1.0
Surrounding Equipment	0.40	1.0
Field Feedback	0.10	0
Existing Documentation	0.20	0
Codes & Standards	0.10	1.0
Total Calculated Certainty Using (1)	0.9	

Framework for Assumptions



Certainty of 200HP?

TABLE III
EXAMPLE A CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	0
Surrounding Equipment	0.40	0
Field Feedback	0.10	1.0
Existing Documentation	0.20	1.0
Codes & Standards	0.10	0
Total Calculated Certainty Using (1)	0.3	

Assumption Impact

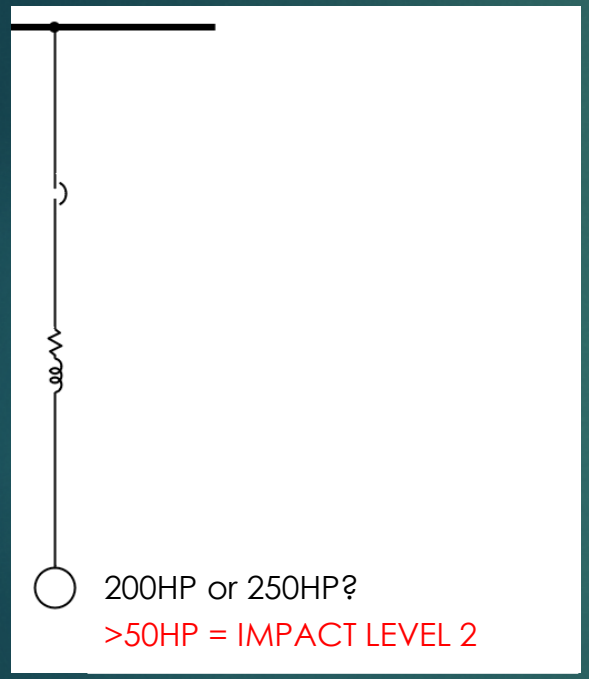
- How does this assumption impact the reliability of the model?
  - 4:More than one bus is majorly affected
  - 3: Downstream connected bus is majorly affected
  - 2: Only large equipment (>50HP/KVA) directly affected
  - 1: Only small equipment (<50HP/KVA) directly affected

Significance

- By combining the certainty of an assumption and the impact it has on the model, we can come up with an overall significance:

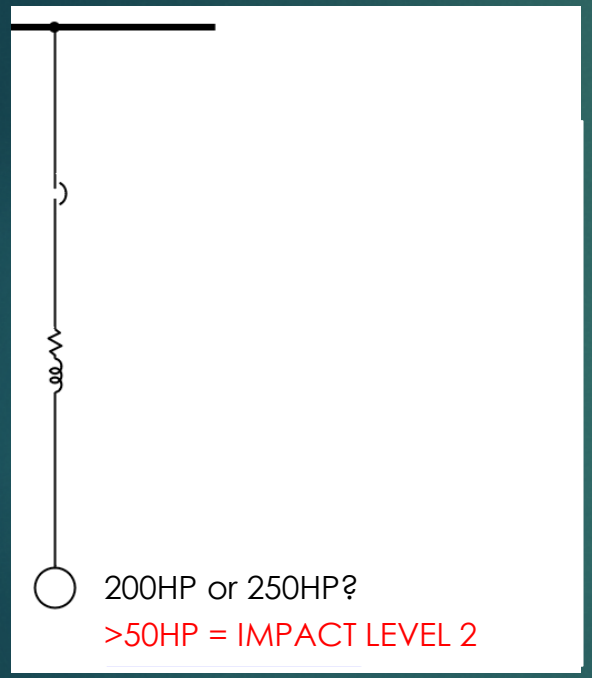
Impact	4	MEDIUM	MEDIUM	HIGH	HIGH
	3	LOW	MEDIUM	MEDIUM	HIGH
	2	NEGLIGIBLE	LOW	LOW	MEDIUM
	1	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	LOW
		C>85%	75%<C<84%	65%<C<74%	<65%
		Certainty Level			

Significance



Impact	4	MEDIUM	MEDIUM	HIGH	HIGH
	3	LOW	MEDIUM	MEDIUM	HIGH
	2	NEGLIGIBLE	LOW	LOW	MEDIUM
	1	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	LOW
		C>85%	75%<C<84%	65%<C<74%	<65%
		Certainty Level			

200HP vs 250HP?



250HP

200HP

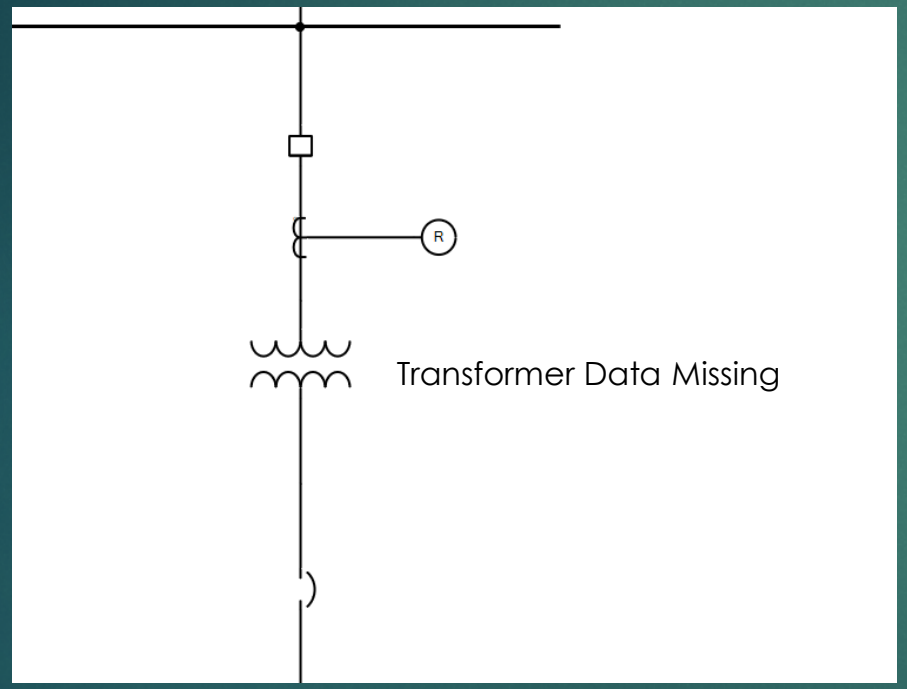
Impact					
	4	MEDIUM	MEDIUM	HIGH	HIGH
	3	LOW	MEDIUM	MEDIUM	HIGH
	2	NEGLIGIBLE	LOW	LOW	MEDIUM
	1	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	LOW
		C>85%	75%<C<84%	65%<C<74%	<65%
		Certainty Level			

$C(250) = 90\%$
$C(200) = 30\%$

Overall Model Confidence

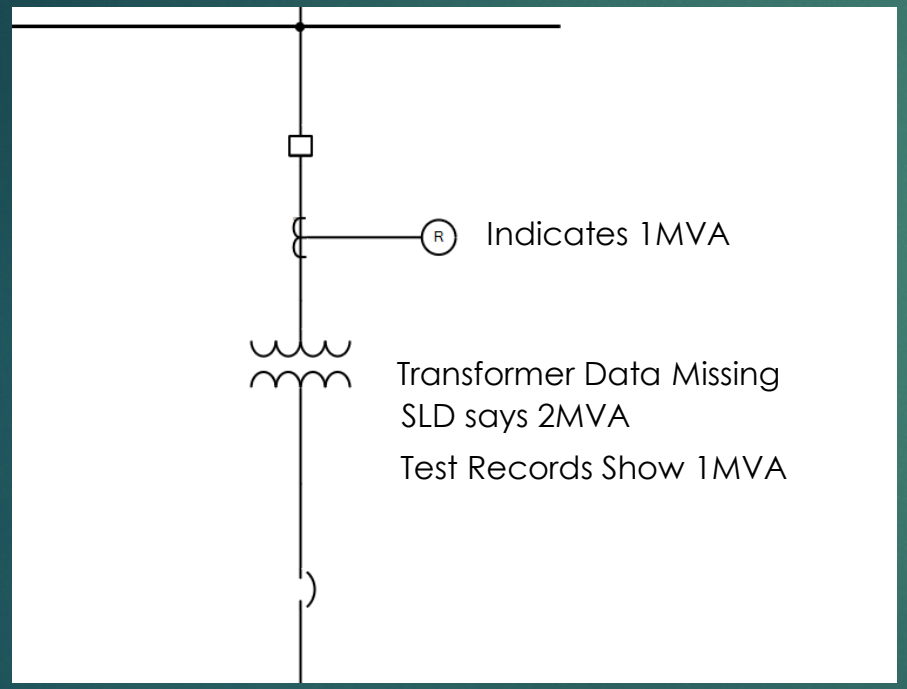
- What is Confidence?
- How many assumptions is too many?

Real World Scenario



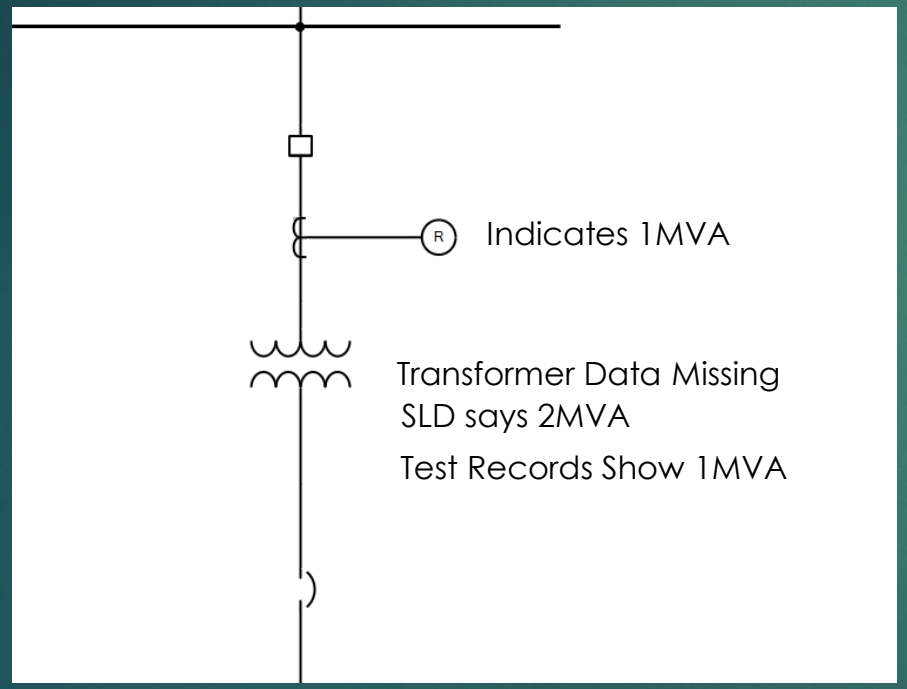
- Missing transformer info.

Real World Scenario - Evidence



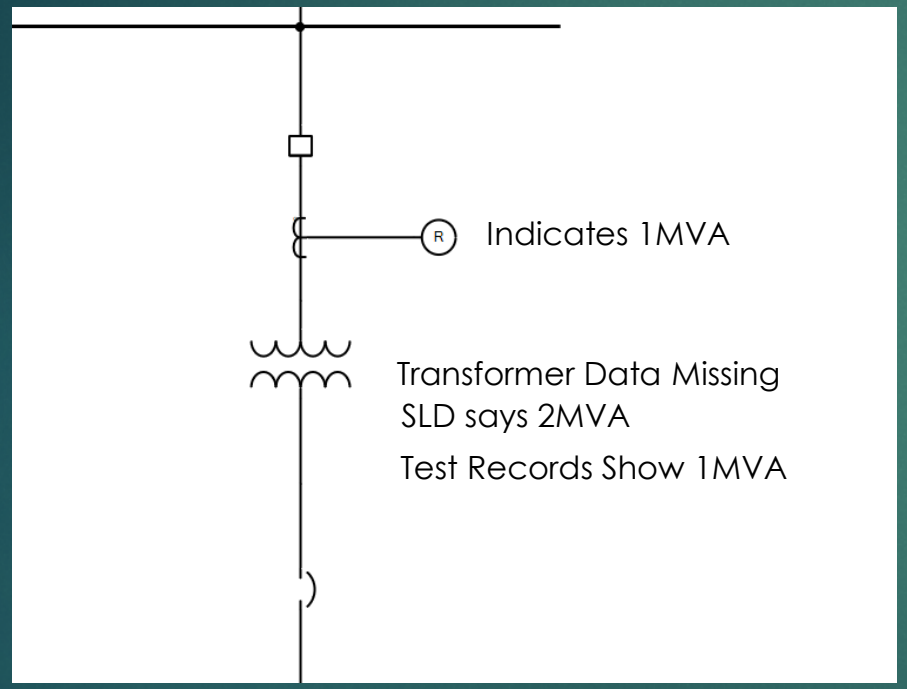
- Maintenance records show 1MVA (older than 5 years).
- Single Lines show 2MVA.
- Primary OCPD relay shows 1MVA, and was tested same time as maintenance records.

Real World Scenario - Evidence



- Maintenance recalls that transformer was replaced ~10 years ago with a smaller one.
- Settings appear to be set to 1MVA, but trip times would not cause nuisance tripping upon energizing a 2MVA transformer, so installation complies with code.

Real World Scenario - Certainty

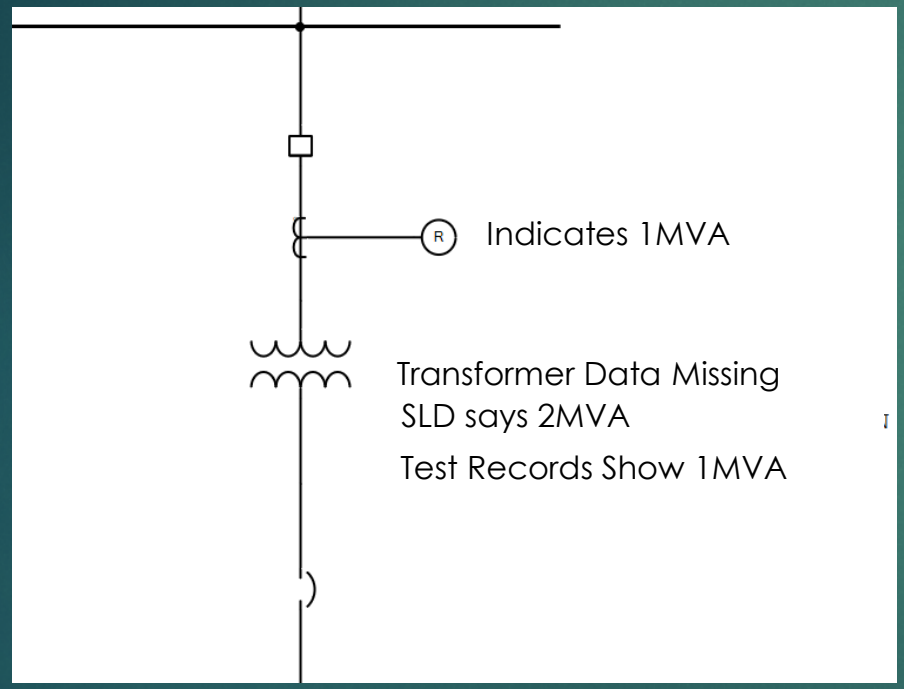


- 1MVA Assumption

TABLE IV
EXAMPLE B CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	1.0
Surrounding Equipment	0.40	0.4
Field Feedback	0.10	1.0
Existing Documentation	0.20	0.0
Codes & Standards	0.10	0.5
Total Calculated Certainty Using (1)	0.71	

Real World Scenario - Certainty

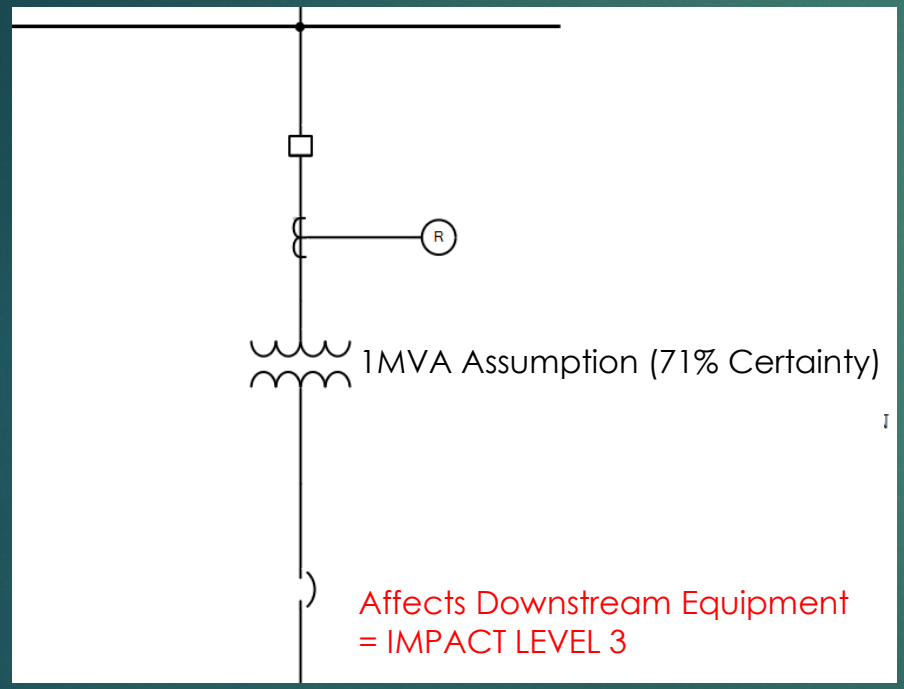


- 2MVA Assumption

TABLE IV
EXAMPLE B CERTAINTY TABLE

Types of Evidence	Certainty & Weights	
	Assigned Weights (W_)	Assigned Certainties (C_)
Maintenance Documentation	0.40	0
Surrounding Equipment	0.40	-0.2
Field Feedback	0.10	0
Existing Documentation	0.20	1
Codes & Standards	0.10	0.5
Total Calculated Certainty Using (1)	0.17	

Real World Scenario - Impact



- Transformer feeds a bus with critical loads and can affect production if taken out of service.
- Due to importance of accuracy, we use a Level 3 impact.

Real World Scenario - Significance

- 1MVA Assumption (71% Certainty)
- 2MVA Assumption (17% Certainty)

Impact	4	MEDIUM	MEDIUM	HIGH	HIGH
	3	LOW	MEDIUM	MEDIUM	HIGH
	2	NEGLIGIBLE	LOW	LOW	MEDIUM
	1	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	LOW
		C>85%	75%<C<84%	65%<C<74%	<65%
		Certainty Level			

Documenting our Assumptions

- Its 3AM and you're on a service call, do you know where your assumptions are?

Documenting our Assumptions

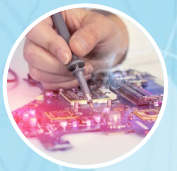
- Appendix A

Assumption Datasheet

Conclusion

- Techniques in data collection discussed here will help to minimize assumptions
- Where assumptions are made, the normalized approach and analysis can help ensure the model is as accurate as possible within the restraints of the project.

Open Discussion and Q&A



Next Meeting: Monday, 04/17/23

Topic: NEC 2023 Update

Presenter: Don Iverson - Manager, Industry Codes & External Relations
North America Operations - Schneider Electric

Thank You and Have a Great Day!