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SOAH DOCKET NO. 473-24-14282
PUC DOCKET NO. 56045

COMPLAINT OF VALERO REFINING-TEXAS, L.P. AGAINST TEXAS-NEW MEXICO POWER COMPANY	§ § § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

VALERO REFINING-TEXAS, L.P.'S RESPONSE TO TEXAS-NEW MEXICO POWER COMPANY'S FIFTH SET OF REQUESTS FOR INFORMATION

Valero Refining-Texas, L.P. ("Valero") files the following responses to the Fifth Requests for Information ("RFI") to Valero filed by Texas-New Mexico Power Company ("TNMP"). The request was filed at the Commission and received by Valero on April 21, 2025. Accordingly, pursuant to the procedural schedule entered in this case and the Commission's procedural rules, Valero's response is timely filed. Valero responses to specific questions are set forth as follows, in the order of the questions asked. Pursuant to P.U.C. Proc. R. 22.144(c)(2)(F), these responses may be treated as if they were filed under oath.

Respectfully submitted,

O'MELVENY & MYERS LLP

/s/ Michael A. McMillin

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ATTORNEYS FOR VALERO REFINING-TEXAS, L.P.

CERTIFICATE OF SERVICE

I, John R. Hubbard, Attorney for Valero, hereby certify that a copy of this document was served on all parties of record in this proceeding on this 1st day of May, 2025 by electronic mail, facsimile, and/or First Class, U.S. Mail, Postage Prepaid.

/s/ John R. Hubbard
John R. Hubbard

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TNMP 5-1 **Please refer to the Rebuttal Testimony of John Duenckel at Page 4, Line 9 through Page 5, Line 3. Admit or deny that Mr. Duenckel specifically recalls the conversation. If you admit, please describe in detail the conversation that Mr. Duenckel recalls, including but not limited to the participants and the identity of the TNMP employee that Mr. Duenckel contends "stated that contact resistance tests or alignment checks on the switch blades are not performed and are not included in TNMP's preventative maintenance protocols for high-voltage switches."**

RESPONSE:

I do not recall the verbal conversation other than the details captured in my notes. I do recall specifically that Vincent Roberts and Chris Gerety were on the call.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-2 **Please refer to Exhibit JD-R-1 and produce it in native format with all metadata intact. Please describe in detail the date Valero located JD-R-1 and why Valero did not produce that document until filing Mr. Duenckel's Rebuttal Testimony.**

OBJECTION:

Valero objects to this because it requests documents or communications that are protected by attorney-client or attorney work product privilege.

RESPONSE:

Exhibit JD-R-1 is a word document that contains copy/pasted text from an otherwise privileged email thread that was withheld on the basis of privilege and identified in Valero's privilege log.

The notes contained in Exhibit JD-R-1 were produced along with Mr. Duenckel's rebuttal testimony because he recalled their existence and brought it to counsel's attention shortly before his rebuttal testimony was due. Upon further review and discussion with Mr. Duenckel, counsel determined that his notes were not privileged and produced the same.

Valero cannot produce the email in its native format without revealing privileged communications. Upon request, Valero would be willing to submit the email in its native format for in-camera inspection by the ALJ to verify its privileged nature.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-3 **Please refer to the Rebuttal Testimony of John Duenckel at Page 4, Line 9 through Page 5, Line 3. Please produce all documents and communications related to or discussing the referenced March 9, 2022, call between TNMP and Valero.**

OBJECTION:

Valero objects to this request to the extent it requests documents or communications that are protected by attorney-client or attorney work product privilege.

Valero objects to this request as overly broad and unduly burdensome because it does not limit the time frame of the requested production.

RESPONSE:

Please refer to Valero's previous productions and the exhibits to its testimony.

Preparer: Counsel
Sponsor: Counsel

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TNMP 5-4 **Please refer to the Rebuttal Testimony of John Duenckel at Page 8, Lines 7-8. Please describe what is meant by the word "outage."**

RESPONSE:

The term outage is used as described in Texas PUC Electric Substantive Rules 25.52.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-5 **Please refer to the Rebuttal Testimony of John Duenckel at page 9, Lines 4-17. Please identify the exact provision of PRC-027-1 that pertains to "settings documentation management" and explain what specifically PRC-027-1 requires pertaining thereto.**

RESPONSE:

Data management (including protection settings) is an industry accepted requirement of PRC-027-1 R1 section 1.2 and 1.3. *See* https://quanta-technology.com/wp-content/uploads/2020/04/CS-PC_PRC-027_V1.1-4-18-2019.pdf as an example.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-6 **Please refer to the Rebuttal Testimony of John Duenckel at page 9, Lines 4-17. Please identify the exact provision of PRC-027-1 that pertains to "as left settings" and explain what specifically PRC-027-1 requires pertaining thereto.**

RESPONSE:

Settings applied on BES elements, as described in PRC-027-1, are "as-left" settings. "As-left" relay settings is an industry accepted term that refers to the relay settings that are configured and left in the protective device after maintenance or testing. *See* example here: https://netaworldjournal.org/archiving-protective-relay-settings/#:~:text=As%2DFound%20Versus%20As%2DLeft,for%20each%20and%20every%20relay.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-7 **Please refer to the Rebuttal Testimony of John Duenckel at page 11, Lines 11-16. Please identify the exact provision of PRC-027-1 that requires personnel to retrieve "as-found" settings from a relay and compare them to the settings the personnel s about to install.**

RESPONSE:

In order to "develop new and revised Protection System settings for BES Elements" as described in PRC-027-1, one must first obtain the existing settings, which are referred to in the industry as "as-found." "As-found" relay settings is an industry accepted term that refers to the existing settings of a protective device that are in place before maintenance or testing begins.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-8 **Please refer to the Rebuttal Testimony of Kevin Mara at page 15, lines 13-15 where he states "While my testimony could have been clearer with respect to why I included the inset picture, it is unfortunate that TNMP's witnesses mis-interpreted my intent with the figure." Admit or deny that Mr. Mara stated in his Direct Testimony on page 15, lines 20-21, that the "confidential figure below is combined photos of the failed switch." Please explain how such statement was mis-interpreted.**

RESPONSE:

Admit the text says "confidential figure below is combined photos of the failed switch." The switch refers to the Pascor Type VBPA switch. Both photos are failures of Pascor Type VBPA switches.

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-9 **Please refer to the Rebuttal Testimony of Kevin Mara at page 40, lines 2-7. Please cite any support Mr. Mara is aware of for this position. Please produce any document, including academic literature or NERC-prepared documents, that describe PRC-027 as a "performance code" and not a "prescriptive code."**

RESPONSE:

The title of the standard is "Coordination of Protection Systems for Performance During Faults." Mr. Mara notes the standard does not have very specific rules defining in detail steps necessary to achieve coordination for performance during fault, but standard allows utilities determine process to achieve the desired performance. Thus this is a performance code.

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-10 **Please refer to the Rebuttal Testimony of Kevin Mara at page 39, line 10 through page 40, line 7. Please identify, with page and line number, where in Valero's direct testimony Valero raised the issue that PRC-027 was a performance standard. If none, please describe in detail the reason it was not raised during Valero's direct testimony.**

OBJECTION:

Valero objects that the information sought by this request is irrelevant because it is not probative to any of the issues raised in this proceeding.

Valero further objects to this request as harassing. TNMP had an opportunity to object to Valero's direct testimony as improper supplemental direct, but chose not to make that objection. Instead, counsel for TNMP agreed not to raise that objection in exchange for the opportunity to file supplemental direct testimony.

RESPONSE:

Pursuant to its objections, Valero is not responding to this request.

Preparer: Counsel
Sponsor: Counsel

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TNMP 5-11 **Please refer to the Rebuttal Testimony of John Duenckel at Page 24, lines 6-21. Please identify, with page a line number, where in Valero's direct testimony Valero alleged TNMP violated IEEE 605. If none, please describe in detail the reason it was not raised during Valero's direct testimony.**

OBJECTION:

Valero objects that the information sought by this request is irrelevant because it is not probative to any of the issues raised in this proceeding.

Valero further objects to this request as harassing. TNMP had an opportunity to object to Valero's direct testimony as improper supplemental direct, but chose not to make that objection. Instead, counsel for TNMP agreed not to raise that objection in exchange for the opportunity to file supplemental direct testimony.

RESPONSE:

Pursuant to its objections, Valero is not responding to this request.

Preparer: Counsel
Sponsor: Counsel

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TNMP 5-12 **Please refer to the Rebuttal Testimony of John Duenckel at Page 23, lines 3-20. Please indicate, with page a line number, where in Valero's direct testimony, Valero alleged TNMP violated IEEE 1427. If none, please describe in detail the reason it was not raised during Valero's direct testimony.**

OBJECTION:

Valero objects that the information sought by this request is irrelevant because it is not probative to any of the issues raised in this proceeding.

Valero further objects to this request as harassing. TNMP had an opportunity to object to Valero's direct testimony as improper supplemental direct, but chose not to make that objection. Instead, counsel for TNMP agreed not to raise that objection in exchange for the opportunity to file supplemental direct testimony.

RESPONSE:

Pursuant to its objections, Valero is not responding to this request.

Preparer: Counsel
Sponsor: Counsel

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TNMP 5-13 **Please refer to the Rebuttal Testimony of John Duenckel at Page 14, Line 18 through Page 15, Line 24. Admit or deny that a single relay misoperation is a violation of PRC-027-1. Please explain the basis of your response.**

RESPONSE:

Deny. TNMP's lack of defined processes and procedures to ensure that relays operated as intended when their designed settings required updates or changes is a clear violation of PRC-027-1.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-14 **Please refer to the Errata to the Direct Testimony of Kevin Mara where he changes his direct testimony with respect to Page 6, Line 10, and Page 7, Line 19, with respect to relay testing. Admit or deny that Valero has withdrawn its allegation that TNMP failed to comply with industry standards for testing relays. If anything other an unequivocal admit, please describe in detail what claim Valero is continuing to allege.**

RESPONSE:

Amit Mr. Mara removed the reference to IEEE C37103 regarding testing of differential relays. Deny that Valero has withdrawn all allegations that TNMP failed to comply with industry standards for testing relays. TNMP failed to conduct adequate post-energization testing of the relay.

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-15 **Please refer to the Rebuttal Testimony of John Duenckel at Page 23, Lines 5-20. Is it Mr. Duenckel's position that if the clearance between the jumper and the reactor was 54" at the time of the Outage, the fault near the reactors would not have occurred? Please explain in detail the basis for your answer.**

RESPONSE:

Mr. Duenckel's position is described in the rebuttal testimony at page 24, lines 17-21 and page 24, line 28 through page 25, line 4.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-16 Please describe Mr. Duenckel's experience, if any, with the negotiation or drafting of interconnection agreements between ERCOT utilities.

RESPONSE:

Neither Valero nor any of its affiliates are ERCOT utilities. However, similar agreements are negotiated and drafted between Valero facilities and their corresponding electric utilities in the form of a GIA (generator interconnection agreement) or parallel operating agreement at such facilities where Valero operates substantial electrical generation sources. Examples of Mr. Duenckel's involvement in such agreements includes agreements between Valero and utilities such as OG&E, PG&E, LADWP, AEP, and National Grid.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-17 **Please refer to the Rebuttal Testimony of John Duenckel at Page 11, Lines 19-21 where Mr. Duenckel states that "the agreements between TNMP and CenterPoint to address that issue appear to have been poorly documented." Please explain in detail the basis of this statement.**

RESPONSE:

The term "agreements" in this context refers to the example emails displayed in the testimony, which are not thorough and adequate documentation of the agreed upon protection philosophy between TNMP and CenterPoint, as further explained in my testimony.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-18 **Please refer to the Rebuttal Testimony of Kevin Mara at Page 12, Lines 2-4 where he states, "The failure to support the jumpers at TNMP's current-limiting reactors also would have resulted in a fault in the future." Please produce any technical analysis, work papers, modeled system conditions, studies or other supporting documentation for this statement.**

RESPONSE:

Reference Mr. Mara's work papers for calculation of magnetic force in Telsa. At 6000 amps the pull on the vertical jumper would be 30.82 lbs per foot of conductor on a jumper that is 10 feet long for a total force of 265.21 lbs.[1] Further at 3000 amps the pull on the conductor would be 15.41 lbs per foot of conductor for a total force of 66.30 lb.[2]

A workpaper is attached to this response.

Preparer: Kevin Mara
Sponsor: Kevin Mara

[1] *See* Attachment Page 4 (converting pounds per foot of conductor into total force).
[2] *Id.*

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TNMP 5-19 **Please refer to the Rebuttal Testimony of Kevin Mara at Page 23, Lines 3-4 where he states, "the purpose of the form is to force the technicians to document what they inspected and what they found – even if the answer is nothing..." Please identify the evidence Mr. Mara relied up to conclude the purpose of the form. Please produce any relevant rule, industry standard, regulatory requirement or other basis that requires technicians to record no issues during substation inspections.**

RESPONSE:

Mr. Mara determined the purpose of the form based on a plain reading of the form. As discussed in Mr. Mara's testimony, the purpose of requiring technicians to report no issues is to promote thoroughness during inspections.

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-20 **Please refer to the Rebuttal Testimony of Kevin Mara at Page 32, Lines 12-14 where he states, "The relay's phase rotation settings did not match its wiring, and that mismatch would have resulted in the mis-operation of the relay regardless of which protection scheme was used." Please provide any technical analysis, workpapers, modeled system conditions, studies or other supporting documentation which was used to arrive at this conclusion.**

RESPONSE:

The evidence is TNMP's admission that the relay mis-operated due to phase rotation not matching for the directional relay. For the Line Current Differential relaying, Mr. Nix stated in his Supplemental Direct (page 3), the relay would trip if the phasing did not match.

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-21 **Please refer to the Rebuttal Testimony of Kevin Mara at Page 6, Lines 14-17 where he states, "… PRC-027-01 is a performance standard which states that the Protection Systems must operate in the intended sequence during faults…" Please identify by page number where PRC-027-1 states that the "Protection Systems must operate in the intended sequence during faults."**

RESPONSE:

Mr. Mara was referencing Section R1 which states "such that the Protection Systems operate in the intended sequence during Faults."

Preparer: Kevin Mara
Sponsor: Kevin Mara

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TNMP 5-22 **Please refer to the Rebuttal Testimony of John Duenckel on Page 9, Line 18-21 where he states, "In fact, TNMP's testimonies are completely silent on any checks or comparisons that were required to be performed by the TNMP engineer who developed the settings to be used for the firmware upgrade and who installed the 'proposed' settings after the firmware upgrade." Please identify any standard, rule, or regulatory requirement that Mr. Duenckel alleges "requires" the engineer to perform "checks or comparisons" to which Mr. Duenckel refers.**

RESPONSE:

PRC-027-1.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-23 **Please refer to the Rebuttal Testimony of John Duenckel on Page 11, Lines 19-21 where he states "However, the agreements between TNMP and Centerpoint to address that issue appear to have been poorly documented, and these differences were often a source of confusion." Please produce all "agreements" that were reviewed by Mr. Duenckel to which he refers in this statement.**

RESPONSE:

"Agreements" are referring to emails, such as the ones included in the testimony.

Preparer: John Duenckel
Sponsor: John Duenckel

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TNMP 5-24 **Please refer to the Rebuttal Testimony of John Duenckel on Page 15, Lines 5-11 where he quotes PRC-027-1. Please admit or deny that the standard seeks to "minimize the possibility of errors that could be introduced in the development of settings," but not "eliminate the possibility of errors that could be introduced in the development of settings."**

RESPONSE:

Admit. Although human errors in protective device settings development and implementation do occasionally occur in public utility systems, TNMP's policies for complying with PRC-027-1 did not provide adequate checks and reviews to minimize human errors and ensure that the "protection system operates in the intended sequence during faults," as required by Section R1 of PRC-027-1. As such, this is not just a case of isolated "human error," as TNMP's witnesses argue. Instead, this was a broader failure to put systems into place that would effectively check for and minimize human error.

Preparer: John Duenckel
Sponsor: John Duenckel

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VALERO REFINING-TEXAS, L.P.'S RESPONSE TO TEXAS-NEW MEXICO POWER COMPANY'S FIFTH SET OF REQUESTS FOR INFORMATION

TNMP 5-25 **Please refer to the Rebuttal Testimony of Kevin Mara on Page 46, Line 15 where he states, "Mr. Leon had no formal training in overcurrent protection on his resume." Please explain in detail the basis for this statement. Please explain in detail the role that overcurrent protection played in the events leading up to the Outage.**

RESPONSE:

Mr. Mara notes that Mr. Leon does not have the same level of training as exhibited on Mr. Vincent's resume. Mr. Leon's resume showed only two independent relay courses prior to the outage. Further, in Mr. Mara's Supplemental Rebuttal, Mr. Mara provided step by step errors made by Mr. Leon which Mr. Mara attributes to lack of training.

Preparer: Kevin Mara
Sponsor: Kevin Mara

SOAH DOCKET NO. 473-24-14282
PUC DOCKET NO. 56045

COMPLAINT OF VALERO REFINING-TEXAS, L.P. AGAINST TEXAS-NEW MEXICO POWER COMPANY	**§ § § §**	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

VALERO REFINING-TEXAS, L.P.'S RESPONSE TO TEXAS-NEW MEXICO POWER COMPANY'S FIFTH SET OF REQUESTS FOR INFORMATION

TNMP 5-26 **Is Valero aware of any authority specifying that most electric utilities comply with ANSI/NETA standards? If yes, please produce a copy of the authority and cite the page number.**

RESPONSE:

Good Utility Practice does not necessarily require an authority to force the actions of an electric utility. Rather, the standards and guidelines within the industry help to define Good Utility Practice. Mr. Mara is not aware of a specific authority requiring the utilities to comply with ANSI/NETA standards.

Preparer: Kevin Mara
Sponsor: Kevin Mara

SOAH DOCKET NO. 473-24-14282
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COMPLAINT OF VALERO REFINING-TEXAS, L.P. AGAINST TEXAS-NEW MEXICO POWER COMPANY	§ § § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

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TNMP 5-27 Admit or deny that Valero complies with all manufacturer recommendations for all equipment in its facility?

RESPONSE:

Valero's documented electrical maintenance practices are based on ANSI/NETA MTS which includes careful consideration of all aspects of test data and condition of maintenance, including manufacturer's published data and recommendations. The purposes of Valero's documented electrical maintenance practices, as with ANSI/NETA MTS, are to assure electrical equipment and systems are operational, are within applicable standards and manufacturer's tolerances, and are suitable for continued service.

Preparer: John Duenckel
Sponsor: John Duenckel

K. Mara Dec 20 2024 Amended to add force calculations 4/30/2025

Equation (2) can be used to estimate the magnetic field based on the current flow

The magnetic field is proportional the current flow.
The reactor is rated for 3,000 amps
Event recording showed 6000 amps on this line
Dimensions from TNMP Response 0000541

Estimate jumper distance from photos

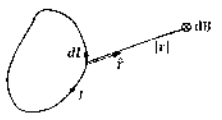
References:
Air Core Reactors: Magnetic Clearances, Electrical Connection, and Grounding of their Supports

Magnetic Field of Power Plant Air Core Reactor

Air Core Reactors:
Magnetic Clearances, Electrical Connection, and Grounding of their Supports

Biot-Savart's law (1) may be applied to calculate the magnetic field of a cylindrical winding [9].

$$dB = \frac{\mu_0}{4\pi}\frac{Idl \times \hat{r}}{|r|^2} \quad (1)$$



dB	magnetic flux density of a short current filament
μ_0	physical constant ($4\pi 10^{-7}\ H/m$)
I	electric current
dl	infinitesimal length of current carrying wire filament
$\hat{r}$	unit vector of vector r
$\|r\|$	distance between current filament and field point

The external magnetic field of a dry-type air-core reactor winding at a significant distance from the winding may be approximated by the field of a current loop as shown in Figure 3. This approximation holds for coils having a winding length shorter than about three times the winding diameter. The field produced by a current carrying winding loop in a distance r of more than around three times the loop diameter may be approximated according to [5] by the equations (2) and (3). (For locations much closer to the reactor, numerical techniques are required.)

$$|B| = \frac{\mu_0 n I D^2}{8 r^3} f(\Theta) \quad (2)$$

$$f(\Theta) = \sqrt{\sin^2(\Theta) + \frac{\cos^2(\Theta)}{4}} \quad (3)$$

Figure 3 - loop, equivalent to a reactor winding

|B|	magnitude of the magnetic field
μ_0	permeability in air (μ_0=4x10^{-7}H/m)
n	no. of turns
I	current
D	loop diameter (mean winding diameter)
r, Θ	coordinates
f(Θ)	directivity function as per (3)

Using (2) and (3) in the lateral direction Θ = 0, f(Θ) = 0.5) the magnitude of the magnetic flux density at moderate distances away from the reactor may be estimated by

$$|B| = \frac{\pi n I D^2}{4 r^3} 10^{-7} \text{ Tesla} \quad (4)$$

0.5

μ_0		4.00E-07		
n		500.00	Unknown value can range from 100s of turns to several thousand turns	
I		6,000.00		
D		121.00	inches or	3.073 Meters
Θ		0.0		
f(Θ)		0.5		
r		3.048006096		

Length of bells	10 ft	
Radius of Reactor	5 ft	
Distance from the reactor	10 ft	3.048006096

$|B| = \frac{\pi n I D^2}{4 r^3}$ x 10^{-7} Tesla 0.08 Telsa

The force on a current-carrying conductor in this magnetic field at the calculated distance from the reactor can be calculated.
For a current-carrying conductor near a magnetic field, the force is given by current * length * magnetic field strength

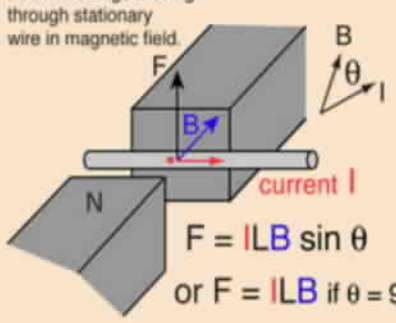
Newtons = amps * meters * Tesla *SIN(Φ)

amps	6000	(nearby conductor amps during event - same level as reactor current)
meters	1	(one unit length)
Tesla	0.07858	(magnetic field generated by reactor at the specified distance)
Φ°	90.00°	(angle between magnetic field lines and conductor current direction)
N/m	449.81	(Newtons per meter of conductor)
lbf/ft	30.82	(pound-fource per foot of conductor)

Not secure hyperphysics.phy-astr.gsu.edu/hbase/magnetic/forwir2.html

Magnetic Force on a Current-Carrying Wire

Positive charge moving through stationary wire in magnetic field.



$F = ILB \sin\theta$

or $F = ILB$ if $\theta = 90$

This relationship arises from the basic magnetic force:

$$F = qvB \sin\theta$$

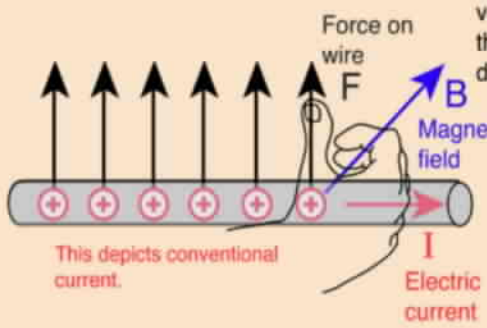
which for a charge q traveling length L in a wire can be written

$$F = q\frac{L}{t} B \sin\theta$$

$$F = \frac{q}{t} LB \sin\theta$$

$$F = ILB \sin\theta$$

The magnetic force on a current-carrying wire is perpendicular to both the wire and the magnetic field with direction given by the right hand rule.



Curl fingers as if rotating vector I into vector B. The thumb is then in the direction of the force F

$\vec{F} = \vec{I}L \times \vec{B}$

Force on straight wire of length L

Index

Electromagnetic force

Magnetic field concepts

If the current is perpendicular to the magnetic field then the force is given by the simple product:

Force = Current x Length x B-field

For current I = 6000 A = 0.6 x 10^ 4 A
and length L = 1 x 10^ m
positioned perpendicular to a magnetic field B = 7.6E-2 Tesla = 760 Gauss
the force is F = 0.456 x 10^ 3 N.
If the angle between the current and magnetic field is 90 degrees
the force is F = 0.456 x 10^ 3 N.

Data may be entered in any of the fields. Whey you have finished entering data, click on the quantity you wish to calculate in the active formula above. The quantities will not be forced to be consistent until you click on a choice. Default values will be entered for unspecified parameters, but all values may be changed.

Magnetic interactions with charge

Magnetic force applications

Conclusions:

Magnetic force on the jumper increases with increase load current

Recorded peak current was 6,000 amps where exceeded the rating of the reactor

Magnetic force is estimated to be over 30 lbs per foot of conductor with 6,000 amps of current

			amps	6000	(nearby conductor amps during event - same level as reactor current)
Magnetic Field Strength where ƒ(Θ)=ƒ(0°)=0.5	0.07858	T	Φ°	90.00°	(angle between magnetic field lines and conductor current direction)
Distance From Field Generator (Reactor) to Conductor at Θ=0°	10.000	ft	Conductor Length	10.0	
			Unit Length For Calculation	0.1667	

F = I*L*B*SIN(Φ)

265.21 lbf total

Unit Length #	Distance Along Conductor From Magnetic Field Point (ft)	r (ft)	Θ	ƒ(Θ)	β (T)	lbf
1	0.00	10.00	0.00°	0.500	0.07858	5.1368
2	0.17	10.00	0.95°	0.500	0.07858	5.1368
3	0.33	10.01	1.91°	0.501	0.07858	5.1368
4	0.50	10.01	2.86°	0.502	0.07857	5.1367
5	0.67	10.02	3.81°	0.503	0.07857	5.1365
6	0.83	10.03	4.76°	0.505	0.07856	5.1360
7	1.00	10.05	5.71°	0.507	0.07855	5.1353
8	1.17	10.07	6.65°	0.510	0.07853	5.1340
9	1.33	10.09	7.59°	0.513	0.07851	5.1322
10	1.50	10.11	8.53°	0.516	0.07846	5.1295
11	1.67	10.14	9.46°	0.520	0.07841	5.1259
12	1.83	10.17	10.39°	0.524	0.07834	5.1211
13	2.00	10.20	11.31°	0.528	0.07824	5.1151
14	2.17	10.23	12.23°	0.533	0.07813	5.1075
15	2.33	10.27	13.13°	0.537	0.07799	5.0983
16	2.50	10.31	14.04°	0.542	0.07782	5.0873
17	2.67	10.35	14.93°	0.548	0.07762	5.0743
18	2.83	10.39	15.82°	0.553	0.07739	5.0593
19	3.00	10.44	16.70°	0.559	0.07713	5.0420
20	3.17	10.49	17.57°	0.564	0.07683	5.0225
21	3.33	10.54	18.43°	0.570	0.07649	5.0006
22	3.50	10.59	19.29°	0.576	0.07612	4.9763
23	3.67	10.65	20.14°	0.582	0.07571	4.9496
24	3.83	10.71	20.97°	0.588	0.07527	4.9204
25	4.00	10.77	21.80°	0.595	0.07478	4.8887
26	4.17	10.83	22.62°	0.601	0.07426	4.8546
27	4.33	10.90	23.43°	0.607	0.07370	4.8181
28	4.50	10.97	24.23°	0.613	0.07311	4.7792
29	4.67	11.04	25.02°	0.620	0.07248	4.7381
30	4.83	11.11	25.80°	0.626	0.07181	4.6947
31	5.00	11.18	26.57°	0.632	0.07112	4.6493
32	5.17	11.26	27.32°	0.639	0.07039	4.6018
33	5.33	11.33	28.07°	0.645	0.06964	4.5524
34	5.50	11.41	28.81°	0.651	0.06885	4.5012
35	5.67	11.49	29.54°	0.657	0.06805	4.4484
36	5.83	11.58	30.26°	0.664	0.06721	4.3940
37	6.00	11.66	30.96°	0.670	0.06636	4.3382
38	6.17	11.75	31.66°	0.676	0.06549	4.2811
39	6.33	11.84	32.35°	0.682	0.06460	4.2228
40	6.50	11.93	33.02°	0.688	0.06369	4.1635
41	6.67	12.02	33.69°	0.693	0.06277	4.1033
42	6.83	12.11	34.35°	0.699	0.06184	4.0424
43	7.00	12.21	34.99°	0.705	0.06089	3.9807
44	7.17	12.30	35.63°	0.710	0.05994	3.9186
45	7.33	12.40	36.25°	0.716	0.05898	3.8560
46	7.50	12.50	36.87°	0.721	0.05802	3.7931
47	7.67	12.60	37.48°	0.726	0.05706	3.7300
48	7.83	12.70	38.07°	0.732	0.05609	3.6668
49	8.00	12.81	38.66°	0.737	0.05512	3.6035
50	8.17	12.91	39.24°	0.742	0.05416	3.5404
51	8.33	13.02	39.81°	0.747	0.05319	3.4774
52	8.50	13.12	40.36°	0.751	0.05223	3.4147
53	8.67	13.23	40.91°	0.756	0.05128	3.3522
54	8.83	13.34	41.46°	0.761	0.05033	3.2902
55	9.00	13.45	41.99°	0.765	0.04939	3.2286
56	9.17	13.57	42.51°	0.770	0.04845	3.1675
57	9.33	13.68	43.03°	0.774	0.04753	3.1070
58	9.50	13.79	43.53°	0.778	0.04661	3.0471
59	9.67	13.91	44.03°	0.782	0.04571	2.9879
60	9.83	14.02	44.52°	0.787	0.04481	2.9294