Pipeline Toolbox Gas (PLTB-G) Module and Applications
Use & Limitations Overview

1**. Overview:**
Please see the below overview for all the modules within the Pipeline Toolbox (PLTB) v20 HUB^{PL}. Within each Module there can be several Applications/Widgets. Furthermore, you will see what application can be used for and what the current limitation is for each application.

Module	Application	Uses	Limitations
Pipeline Testing	Pipeline Hydrostatic Testing	Hydrostatic testing is method to determine strength, expose defects, expose leak & validate integrity of the vessel. Typically, tests are conducted at 125% of MAOP.	These tests are limited to defects that ready to failure such as cracks. The test pressure must be adjusted for the related allowable stress at the design temperature. This require adjustments during the testing phase due to ambient temperature conditions
	Pipeline Pressure Testing - Max Pressure Drop	Maximum pressure drop is performed by balancing changes in the measured pressure in the test section against the theoretical pressure changes calculated from changes in the measured temperature of the test section.	Ambient temperature swings can cause challenges regarding pressure changes. Temperature gauges must far enough away from exposed piping to avoid erroneous readings.
	Pipeline Blowdown - Time/Volume Lost	Based on SW Research Report calculations for the blowdown time and mass of gas is vented to atmosphere to a piping system. Accurate to within a few percent.	Blowdown time is impacted through constricting valve changes from sonic (choked) flow to subsonic. This is because of the pressure ratio across the valve is unknow.
	Purging Calculations	Method A - Finding the flow rate through the blow off valve(s) using a modified Weymouth formula for critical velocity. Method B where pipe section is assumed to be filled with air prior to purge.	Blow off pressure should be between 18-20 psi and maintained. Blow off coefficient of valve must be known.
	Pack in Pipeline	Calculates using gas packed in an isolated section of the pipe. It uses PLTB Gas Lost in a Full-Bore Rupture calculation in the Accidental Release Module.	Upstream and downstream pressures must be known at the time of calculation. In addition, the actual internal diameter and gas temperature can change the results for accounting purposes.

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RSTRENG	Evaluating Remaining Strength of Externally Corroded Pipe *Most Methods use a Level 1 assessments which only measures max. length and depth.*	This uses a Level 2 method to make more detailed corrosion pit (metal loss) measurements along the axial length of the pipe, RSTRENG can assess Maximum Safe Pressure, Burst Pressure and the Effective Area.	All assessments are limited to weldable line type pipe. Other factors include secondary stresses, cracking, stress risers, etc.

Module	Application	Uses	Limitations
Pipeline Compressor	Centrifugal Compressor - Adiabatic Head	Using the centrifugal compressor application resists when the head is developed by increasing gas velocity to create kinetic energy. As compression ratio drops, adiabatic efficiency drops.	Does not take into the heat gained or lost.
	Centrifugal Compressor - Required Adiabatic Horsepower	This application uses a compression unit that calculates a natural gas-fired turbine to turn a centrifugal compressor. The centrifugal compressor is like a large fan inside a case, which pumps the gas as the fan turns.	Size of the fan and speed within the case controls the pumping action.
	Centrifugal Compressor - Required Polytropic Horsepower	This application uses initial impeller speed and final impeller rotational speed to determine final flow rate, compression head and final shaft Horsepower (HP)	Difficult to determine efficiency which is based on the ratio of specific heat for the gas being used in the compressor.
	Centrifugal Compressor - Fan Laws	This application uses the affinity laws to calculate the volume capacity, head when the speed of the impeller is changed.	Understanding the ratio of specific heat for the gas being used in the compressor.
	Reciprocating Compressor - Cylinder/Equivalent Capacity & Horsepower	This application uses a positive displacement compressor model to deliver gases at high pressures.	Final outlet temperature is a concern.
	Compressor Station Piping - Pipe Diameter	This application uses gas velocity and flow rates to determine the pipe diameter for station piping.	This calculation is a minimum requirement.
	Compressor Station Piping - Pipe Wall Thickness	This application is based on the design pressure required for the suction and discharge piping.	Additional wall thickness may be required for concurrent external load and other factors within Barlow's formula.
	Compressor Station Piping - Gas Velocity	This application pressure, flow rates, internal diameter, temperature(s) and other factors to determine the flow rate.	Gas velocity sound does not exceed 2000 ft/min
	Local Atmospheric Pressure Calculation	Local atmospheric the average air pressure at sea level at a temperature of 15 C (59 F).	Local atmospheric pressure is used in most pipeline and compressor applications and must be temperature compensated.

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Regulators & Meters	Regulator & Station Piping Sizing	This application measures the volumetric flow and pressure reduction to size regulators to feed gas distribution systems.	Subsonic and sonic flow conditions must be considered. Subsonic below 1 Mach and Sonic above 1 Mach.
	Orifice Meter - AGA 3, Method I	This calculation is more general and uses the coefficient of thermal expansion for the various metallic materials for orifice and meter tubes related to temperatures, pressures and natural gas mixture.	These calculations have a heavy dependence on temperature, pressure and gas composition.
	Orifice Meter - AGA 3, Method II	This calculation is more detailed and uses the coefficient of thermal expansion for the various metallic materials for orifice and meter tubes related to temperatures, pressures and natural gas mixture.	These calculations have a heavy dependence on temperature, pressure and gas composition.

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Pipeline Facilities	Reinforcement of Welded Branch Connection	This application assesses the need for reinforcement when using this type of connection from a branch to the main line.	Determining the size and SMYS of the pad to avoid weld cracking to any of the components.
	Relief Valve Sizing	This application calculates for a given set of upstream conditions i.e. nozzle pressure; then the mass rate of flow through the nozzle is reached at the throat or critical flow rate.	Under critical flow conditions, the actual pressure in the throat cannot fall below the critical flow pressure even if a much lower pressure exists downstream.
	Relief Valve Reaction Force	This calculation determines the force at the point of discharge of a pressure relieving device.	API 520 indicates that the equation is for elbow and vertical exhaust pipe.
	Hot Tap Sizing	Hot Tap sizing determines when a fluid is passed through an orifice, the rate of flow of orifice opening absolute downstream pressure.	When flow velocity is equal or less than the critical ratio, the downstream pressure no longer effects the rate of flow through the orifice.

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Miscellaneous	API 1104 Weld Imperfection Assessment - Alternating Acceptance Standards for Girth Welds **(Miscellaneous)**	API 1104 based on empirical criteria for workmanship. Fitness for purpose criteria requires a minimum of 0.005 or 0.01 inches CTOD toughness. Provide inspection and acceptance limits on for imperfections.	Requires skilled practitioners with demonstrated knowledge of fracture mechanics and pipeline load analysis.
	API 1117 Movement of In-Service Pipeline	Movement of in-service Pipelines is calculated to conform elastically to a given trench profile.	Longitudinal Stress due to bending/elongation and elastic curvature must be considered.

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Hydraulics (Gas)	Darcy-Weisbach	Darcy-Weisbach equations are valid for steady state flow. The friction factor - λ -depends on the flow, (laminar, transient, turbulent, Reynolds number) and the internal roughness of the pipe. The friction coefficient can be calculated by the Colebrook-White equation.	Depends on the flow regime for the right friction factor or coefficient.
	Panhandle A	The Panhandle A uses an empirical efficiency factor of 0.92 for partially turbulent flow conditions. It is suitable for Reynolds numbers from 5 x 10 6th power to 11 x 10 6th power. The program calculates upstream, downstream, flow rates and internal diameter.	Smaller diameter lines such as 12" and below, the efficiency factors need to be reduced.
	Panhandle B	The Panhandle B is used in the design of large diameter high pressure long transmission lines. It is suitable for Reynolds numbers from 5 x 10 6th power to 11 x 10 6th power. Fully turbulent regions the Panhandle B are recommended. The program calculates upstream, downstream, flow rates and internal diameter.	Restricted to larger pipe diameter lines and lines that interconnected.
	Weymouth	Weymouth equations are used for distribution, branch laterals and gathering systems. It was originally developed from data taken on small, low to medium pressure pipelines. The program calculates upstream, downstream, flow rates and internal diameter.	For gas transmission through long pipelines, the Weymouth equation is not recommended.
	AGA Fully Turbulent Flow	AGA equations are recommended for fully turbulent regions. The program calculates upstream, downstream, flow rates and internal diameter.	There are AGA equations not meant for turbulent flow regions.
	Colebrook-White	This equation is recommended for use by those unfamiliar with pipeline flow equations, since it will produce the greatest consistency of accuracy over the widest possible range of variables.	This equation is limited for use when the Reynolds number exceeds 4000.
	FM - Fundamental Equation	The Fundamental or General Flow equation is used for calculating the pressure drop in a gas pipeline, considering the pipe diameter, length, elevations along the pipe, gas flow rate and the gravity and compressibility of the gas.	Limited to general use type applications.

	IGT Distribution Equation	The IGT is similar to Panhandle and Weymouth calculations; however, it has been used to determine pressure drop in a pipe with varying flow rates.	The IGT equation produces a large amount of error, decreasing with increasing flow rate.
	Mueller - High Pressure	The Mueller High Pressure equation is used to calculate upstream/downstream pressures, flow rate and internal diameter in distribution systems with pressures greater than 1 psig.	The pressure calculations should be limited to greater than 1 up to 125 psig.
	Mueller - Low Pressure	The Mueller High Pressure equation is used to calculate upstream/downstream pressure, flow rate and internal diameter in distribution systems with pressures less than 1 psig.	This calculation is limited to after meter to a residence i.e. short length piping and less than 1 psig.
	Pittsburgh	The Pittsburgh equation is used to calculate upstream/downstream pressure, flow rate and internal diameter in low pressure pipelines within the following range: (D < 6", P > 1.5psi).	This calculation is used for natural gas distribution piping to subdivisions and commercial areas.
	Spitzglass	The Spitzglass equation is recommended for low pressure vent lines that are less than 12-inch diameter.	Limited to low pressure vent lines.

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Steel Pipe Design & Stress Analysis	Design Pressure	Determine design pressure given pipe specs that must meet the requirements of industry standards ASME B31.4 and B31.8 to operate safely regarding stress.	Each component of the pipeline must be able to withstand operating stresses and loadings without impairment of its serviceability.
	Minimum Wall Thickness	Determine minimum wall thickness needed to achieve desired MAOP in a given class location (design factor)	Unanticipated metal loss due to corrosion, strain limits due to overburden, third party damage and fault movements along the pipe.
	Flume Design	Estimating the roughness in hydraulic computations associated with natural streams, floodways and excavated channels.	Irregularity of the surface of the channel sides and bottom, variation in shape and size, obstructions, vegetation and meandering of the channel.
	Restrained Pipeline Stress Analysis	Restrained pipes are typically buried with proper bedding. However, when settlement or subsidence occurs the longitudinal and combined stresses may be replaced with a strain limit of 2% in ASME B31.4	Yielding that does not impair the serviceability of the pipe. Local stresses caused by periodic or repetitive load resulting in fatigue. Unanticipated earthquakes vibration and thermal expansion.
	Unrestrained Pipeline Stress Analysis	Unrestrained pipes are unburied or spans where the pipe is bedded or supported beam. These could be designed or mother nature exposing the pipe due to flooding or other natural causes.	Allowable expansion stresses sustained and occasional loads that are greater than 80% stress. Thermal expansion greater than 75% of SMYS.

	Buoyancy Analysis & Concrete Coating Requirements	Determine the buoyance of the specified underwater pipe based on the required thickness of concrete coating to counter the buoyancy forces.	Does not account/allow for depth of water or burial. PLTB input is unit weight of water.
	Buoyancy Analysis & Concrete Weight Spacing	Determine downward forces and weights of the specified pipe based on the spacing of weights to counter the buoyance forces.	Does not account/allow for depth of water or burial. Calculation must be done outside of PLTB
	Pipe Anchor Force Analysis	Determine stresses and deflections in pipelines at the transition from below ground (restrained) to above ground (unrestrained) to determine if an anchor is required for above ground pig traps or other piping facilities.	Internal pressure, temperature change, flexibility of to absorb a degree of lateral anchor movement
	Maximum Impact Load & Penetration Depth	Assessment of strain due to a falling object such as a piece of construction equipment, material or vehicle falls over an operating pipeline.	Drop height, maximum load at the soil surface, type of soil, etc. to determine the penetration depth.
	Internal Pressure - % SMYS	Calculation provides the maximum internal pressure given pipe specs and % SMYS. These factors are used in the design of roads and railroads. Pressure in the pipe i.e. gauge.	External loading on the pipe is additive and must be considered separately using PLTB API 1102 external loading calculations.
	Hoop Stress & Longitudinal Stress	These stresses are used in most calculations for road and RR crossing, spans, blasting, streams, etc. before deciding on the safety of the pipe.	Live hoop and longitudinal stress must be below seam and girth weld fatigues limits. Outside force stresses must be known for proper evaluation.
	Bending Stress & Deflection	This application is related bending stresses and deflection on a uniformly loaded span. The weight of the pipe and product.	If there is more than one loading, superimposing individual solutions will be required. To account for unknow stresses multiply the longitudinal stress by 1.1.
	Linear Thermal Pipe Expansion	Buried pipe must include pre-existing operational stresses. These includes hoop, longitudinal stress due to thermal expansion. Outside force stress must be added to these stresses before any evaluations can be performed as in PLTB.	The thermal stress is difficult to estimate because of unknown installation temperature. It can be estimated from local climatic data.
	Requirements to Move Unpressured Pipe	This application is related to maximum movement (deflection) at the end of pipe with no pressure.	The greater the deflection requires a larger distance of exposed pipe to minimize the strain on the pipe.
	Bending Stress Caused by Fluid Flow Around Pipe	This is the result of erosion that increase span length (exposed pipe) where the PLTB applications calculates the longitudinal stresses that estimates the forces on the pipe due to water flow. The same techniques can be used as spans.	Vortex shedding and the potential for fatigue failure of the pipe in flowing water, the apparent weight of the pipe will change because of buoyant forces. Flow velocity is sometime difficult to estimate at different depths i.e. drag and lift.

	Maximum Allowable Pipe Span Length	API 1117 Movement of In-Service Pipelines using the free span between pipe supports. PLTB predicts stresses due to pipe movement of in-service and out of service lines as well as operating pipelines having unintended free spans.	Based on a four-span loaded beam. Because there are many variables during the construction movement of the pipe to the new lowered bedding position, this puts limits on the stresses that can be calculated.

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Polyethylene Pipe - HDD	Pull Force & Installation Stresses	Combined tensile, bending and external hoop stresses that occur simultaneously during the pull process.	The total calculated combined stress should not exceed 100% of SMYS.
	Allowable Tensile Load for PE Pipe During Pull-In Installation	Tensile load is the sum of tensile stress due to the pullback force, hydrokinetic force and bending.	Tensile Stress due to the pullback should not exceed the permitted tensile stress for the pipe. It is also temperature dependent that could result in creep deformation.
	Post Installation Loads and Deflection	Safe long-term deflection design and loads relies on the staying within the standard dimension ratio or SDR values.	Factors to be considered are deflection, ovality, critical collapse pressure and buckling.

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Steel Pipe - HDD	Pull Force and Installation Stress Analysis	Combined tensile, bending and external hoop stresses that occur simultaneously during the pull process.	The pipe's stiffness as it moves through the curves in the bore hole especially. Increasing the radius bends and clearance with the bore hole reduces this effect.
	Operating Stress Analysis	Same stresses experienced in a pipe installed by HDD are the same as open cut and backfill techniques except for elastic bending.	The bending stresses imposed by HDD installation need to be checked in combination with other longitudinal and hoop stresses to ensure allowable limits are not exceeded.

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Pipe Blast	Single Point Explosive Charge	Single point or charge is used in estimating the stress magnitudes to the pipe.	Proximity to the closest single charge.
	Single Point Parallel Line Explosive Charge	Parallel explosive charge are complex methods which have been simplified in many cases to into equivalent parallel line or point sources.	The estimate of the standard error for parallel equations can be as high as 34%; However, if the standoff distance between the pipe and explosive line is greater, then it can be approximated by a single point source.
	Single Point Angled Line Explosive Charge	An angled-line source that is simplified into an equivalent parallel line source if the its standoff distance is equal to or less than the effective length of the line.	Uses a point source solution that simplifies methods for an angled line source.

	Complex Parallel Grid Explosive Charge	Radial ground motions are in a direction perpendicular to the explosive line. The effective length (L) of the equally spaced line of charges is the number of charges multiplied by the spacing between them.	Prediction methods developed are general enough to provide reasonable stress estimates over a fairly wide range of scaled parameters. Some exceptions to the general procedures will exist as a result of particular explosive geometric configurations i.e. 90 degrees
	Complex Angled Grid Explosive Charge	The pipe stress and ground motion is a method that would yield reasonable stress estimates by simplifying this source into an equivalent parallel line or point source.	Prediction methods developed are general enough to provide reasonable stress estimates over a fairly wide range of scaled parameters. Some exceptions to the general procedures will exist as a result of particular explosive geometric configurations i.e. 90 degrees.

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AGR & GPRA	Accidental Gas Release - Small Hole in Pipeline	Gas release rate would be calculated by the small hole model. When the hole diameter in pipeline is relatively small, the pipeline is considered as a tank.	The value of the release rate at the orifice depends on whether gas flow is choked/ sonic or subsonic.
	Accidental Gas Release - Full Bore Rupture	Gas release rate is from peak initial release rate from single side and both sides.	Limiting factors include effective hole diameter and pressure differential.
	Gas Lost in Section of a Full-Bore Rupture	Gas lost is a calculation is a full-bore rupture where an accidental release occurs on both ends of the pipe under subsonic conditions.	Limitations include pressure, location, size of pipe, time to isolate, etc. with two separate ends.
	Width, Radius and Depth of Crater - Pipeline Rupture	Natural gas rupture includes three (3) models that determine depth, radius and Width of the crater. Gasunie, NEN 3651 Radius of Crater and PRCI/Gasunie//Battelle combined model	Limitations include pressure, location, size of pipe, time to isolate, etc. with two separate ends.

Module	Application	Uses	Limitations
External Corrosion Direct Assessment	Remaining Life of Corroded PLs & Reassessment Interval for ECDA Region	Where corrosion damage has occurred and is continuing (corrosion rate) to occur, remaining life calculations are required to determine the next reassessment interval.	If the corrosion rate is unknown, then a 16 mil/year corrosion rate must be assumed. This is a very conservative value which requires shorter reassessment interval to determine the integrity of the structure.
	DCVG-% IR Drop	Direct Current Voltage Gradient (DCVG) is a test method to determine where the location and size of coating defects.	DCVG is influence by other impressed current systems as well as environmental factor such as soil resistivity that may affect the readings.

Module	Application	Uses	Limitations
Steel Pipeline Crossings	Steel Pipeline Crossings Railroads & Highways	API 1102 Design of Roads and Railroad crossings using trenchless methods to design road and railroad crossings	Auger boring and 10’ depth calculations. Many crossings are much deeper. However, most in-situ testing done was limited to ten (10) feet.
	Wheel Load Analysis	The Wheel Load Analysis Program is designed to calculate the overburden and vehicle loads on buried pipe with a Single Layer System (soil only) or a Double Layer Systems (timbers, pavement and soil).	Soil load on pipe is assume that backfill soil slides down without friction, pipe is supported by itself and does not assist in the support.
	Track Load Analysis	The Track Load Program was designed to calculate the overburden and track loads on buried pipe with a Single Layer System (soil only).	Soil load on pipe is assume that backfill soil slides down without friction, pipe is supported by itself and does not assist in the support.
	GPTC Design of Uncased Pipe Crossing	Design of Uncased Pipeline Crossings where conditions for design are out of the scope and limitations of API 1102 & PC Pisces.	Total calculated combined stress should not exceed 100% of SMYS (Safety Factor of 1). GPTC Guide sets Impact factor at 1.5 for non-ridged piping. Recommend for RR crossings an impact factor of 1.75.

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Cathodic Protection	Estimated Weight of a Magnesium Anode	Small underground piping systems such as meter stations, crossovers and short laterals.	Underground piping structures that require a limited current of 1 amp or less due to the limited driving voltage. In addition, where soil resistivities are greater than 5,000-ohm cm.
	Resistance to Earth of an Impressed Anode Ground Bed	Large underground piping systems such as pump/compressor stations and large transmission piping systems.	These systems are not practical for 1 amp or less with low driving voltages. In addition, impressed current system require an AC power source to operate a rectifier to convert AC to DC power.
	Rudenberg's Formula for the Placement of an Anode Ground Bed	This formula considers the attenuation of the pipe to determines the required structure voltage based on the current output.	This formula is very theoretical just using pipe parameters. Other factors to be considered include the presence of foreign metallic structures, accessibility and availability of a power source which are not included.
	Resistance to Earth of a Single Vertical Anode	These calculations are the basis for other calculation which require the effective soil resistivity at that location. Once this value is obtained grounding charts like Dwight’s curves can be used to determine multiple anodes as required. The calculation is used in the AC Power Tool Program as a basis for a distributed anode mitigation system.	This calculation is just for a single anode which requires other calculations and or charts such as Dwight’s curves for grounding. It is the basis for other calculations such as multiple or distributed anodes.

	Resistance to Earth of Multiple Vertical Anodes	This is a common type impressed current ground bed system used to cathodically protect large segments of pipelines as well as pump or compressor station piping.	It requires many anodes to be effective in either multiple i.e. in line perpendicular as specific intervals to the pipeline system or distributed (random) as used in station piping.
	Resistance to Earth of a Single Horizontal Anode	This is common type anode system for linear type anode systems for parallel mitigation for AC Mitigation.	These systems require long lengths of copper cable for grounding or mixed metal oxide to be effective.
	Resistance to Earth of Multiple Horizontal Anodes	Like vertical is a common type impressed current ground bed system used to cathodically protect large segments of pipelines as well as pump or compressor station piping.	It requires many anodes to be effective in either multiple i.e. in line perpendicular as specific intervals to the pipeline system or distributed (random) as used in station piping.
	Required Number of Anodes & the Total Current Requirement	These calculations are the basis for cathodically protecting underground piping structures.	Spacing requirements of anodes can drive up the costs of the cathodic protection impressed current system
	Power Consumption of a Cathodic Protection Rectifier	Rectifiers require AC power to drive the cathodic protection system on a 24-hour basis.	High resistance ground beds can drive up the cost AC power.
	Cathodic Protection Attenuation Calculation	Where long distances are covered by impressed current systems, voltage drops occur along the structure in a reduction fashion of voltages and currents.	Reductions can be significant depending on the current demand and voltage drops. This may require additional cathodic protection for the pipeline system.

Module	Application	Uses	Limitations
Pipeline Corrosion	ANSI B31G - Evaluation of MAOP in Corroded Areas	Using a Level 1 ASME B31.G calculation is a quick method to assess the MAOP of the corroded area.	Limited to Level 1 calculations such as ASME B31.G and Modified ASME B31.G
	ANSI B31G - Maximum Allowable Longitudinal Extent of Corrosion	Using a Level 1 ASME B31.G calculation is a quick method to assess the Maximum Allowable extent of the corroded area.	Limited to Level 1 calculations such as ASME B31.G and Modified ASME B31.G
	Rate of Electrical Current Flow Through the Corrosion Cell	The presence of an electrolyte and a solution between two metals or electrodes for galvanic corrosion to occur.	Size and type of the electrode and resistivity of the solution.
	Relationship between Resistance and Resistivity	Electrical resistance is in ohms and Electrolyte resistivity is in ohm-cm or ohm-m	In practice electrolyte resistivity is used in corrosion related circuits and electrical resistance is in electrical circuits.
	Electrolyte Resistance from Surface of an Electrode to any Distance	Electrolyte resistance from the surface of an electrode to a specified distance through a solution.	These circuits are used for measuring the resistance of solutions or gases to measure an ohmic IR drop through a material or solution.
	Ohm's Law for Corrosion Current	Comparing the potential difference between an anode and cathode to the geometry factor a corrosion current can be calculated.	Establishing the geometry factor and measurement of the anode and cathode on a small surface of specimen.
	Electrical Resistance of a Conductor	A conductor is any material that will allow an electrical current to flow through it. The ability of any conductor in an electrical circuit to pass current is determined by its resistance.	Size of wire, corrosion, temperature, etc. can restrict the flow of electrical current through the conductor i.e. small wire.

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Polyethylene Pipe - Design & Stress Analysis	Design Pressure - Polyethylene Pipe	Polyethylene Line Pipe is designed in accordance to API 15LE based on material designation of specified pipe size and wall thickness, standard dimension ratio, temperature and design factor i.e. 0.32.	Limitations include pressure in distribution and class 3/4 areas, temperatures below -20 degrees and above 150 F, wall thickness, and certain type of materials.
	Wall Thickness - Polyethylene Pipe	Wall thickness must meet minimum thickness in accordance to DOT 192.123.	Early versions must meet minimum requirements such as 6 inch must have a minimum of 0.100 inches.
	Distributed Static Surcharge Load: PE Pipe Directly Beneath a Surcharge Load	In this approach the active earth force is calculated due to simultaneous effect of both the soil weight and the surcharge of strip load over the pipe to determine earth pressures.	To obtain equilibrium conditions with limited analysis.

	Distributed Static Surcharge Load: PE Pipe Not Directly Beneath a Surcharge Load	Similar approach to directly below, the active earth force is calculated due to simultaneous effect of both the soil weight and the surcharge of strip load over the pipe to determine earth pressures.	Obtaining equilibrium conditions with limited analysis.
	Live Load: Aircraft Load on Buried PE Pipe	This calculation applies to 180,000 lb. dual tandem gear assembly with 26 in spacing between tires and 66 in center to center with 12" rigid pavement.	Heavier or larger aircraft such as military type.
	Live Load: AASHTO H20 Load on Buried PE Pipe - 12" Thick Pavement	This calculation determines the rating that can support vehicle loading up to AASHTO H-20 of 32,000 lbs. per axle or 16,000 per wheel.	Loaded vehicles that exceed the ratings such as Fire Trucks.
	Live Load: AASHTO H20 Load on Buried PE Pipe - Unpaved or Flexible Pavement	This calculation determines the rating that can support vehicle loading up to AASHTO H-20 of 32,000 lbs. per axle or 16,000 per wheel.	Roads with a crushed aggregate material above a base to override support for pavement or unpaved surface to handle vehicles that exceed ratings.
	Live Load: Single Wheel over Buried PE Pipe - Concentrated Point Load	This calculation determines the deflection or structural damage to the repeated load application on buried PE pipes with adequate soil cover subjected to concentrated point single wheel loads.	Concentrated heavy loading, inadequate cover, and unstable soils.
	Live Load: Multiple Wheel over Buried PE Pipe - Concentrated Point Load	This calculation determines the deflection or structural damage to the repeated load application on buried PE pipes with adequate soil cover subjected to concentrated point multiple wheel loads.	Concentrated heavy loading, inadequate cover, and unstable soils.
	Live Load: Multiple Wheel Not Over Buried PE Pipe - Concentrated Point Load	This calculations determines the deflection or structural damage to the repeated load application not over buried pipe i.e. parallel.	Concentrated heavy loading, inadequate cover, and unstable soils.
	Live Load: Distributed Surface Load on Buried PE Pipe - Unpaved Road Only	This calculation determines the deflection or structural damage from wheel imprint/Contact area and higher impact factors as needed.	Concentrated heavy loading, inadequate cover, and unstable soils.
	Live Load: Cooper E-80 Railroad Load on Buried PE Pipe	This calculation based on normal RR loading and analyzed for depths of cover from 6 to 14 feet.	Heavier or larger rail hauling RR cars.