



Technology Readiness Levels

Pipeline Research Council International

Pipeline R&D Specific

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Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine technology readiness levels. TRL 1 is the lowest and TRL 9 is the highest.

Note: projects are not ranked or ‘scored’ based on where they are by TRL. TRL is to drive discussion about what has to be done and how long it will take to get to deployment.

When a technology is at TRL 1, scientific research is beginning and those results are being translated into future research and development. TRL 2 occurs once the basic principles have been studied and practical applications can be applied to those initial findings. TRL 2 technology is very speculative, as there is little to no experimental proof of concept for the technology.

When active research and design begin, a technology is elevated to TRL 3. Generally both analytical and laboratory studies are required at this level to see if a technology is viable and ready to proceed further through the development process. Often during TRL 3, a proof-of-concept model is constructed.

Once the proof-of-concept technology is ready, the technology advances to TRL 4. During TRL 4, multiple component pieces are tested with one another. TRL 5 is a continuation of TRL 4, however, a technology that is at 5 is identified as a breadboard technology and must undergo more rigorous testing than technology that is only at TRL 4. Simulations should be run in environments that are as close to realistic as possible. Once the testing of TRL 5 is complete, a technology may advance to TRL 6. A TRL 6 technology has a fully functional prototype or representational model.

TRL 7 technology requires that the working model or prototype be demonstrated in a pipeline application or environment. This could also be a test at a large scale facility such as the Technology Development center (TDC). TRL 8 technology has been tested and “field qualified” and it's ready for implementation into an already existing technology or technology system. Once a technology has been "field proven" during a successful application, it can be called TRL 9.

Not all projects will start at TRL 1 but all should progress to TRL 9 to derive value from the research and development. TRL 9 can look very different and expectations of what TRL 9 looks like should be understood early on in the design of a research project “start with the end in mind”.



PRCI		
TRL 1	Initiation	Basic principles observed and reported
TRL 2	Concept	Technology concept and/or application formulated
TRL 3	Proof of Concept	Analytical and experimental critical function and/or characteristic proof-of-concept
TRL 4	Integration	Component and/or bench configured validation in laboratory environment
TRL 5	Demonstration	Component and/or bench validation in relevant environment
TRL 6	Prototype	System/subsystem model or prototype demonstration in a relevant environment
TRL 7	Pre-production	System prototype demonstration in a field environment
TRL 8	Production	Actual system completed and "field qualified" through test and demonstration
TRL 9	Field Proven	Actual system "field proven" through successful application operations

Supplementary Data:

API 17N has published its own version of TRL's which are slightly different from above and includes only seven levels. The PRCI TRL's shown here are consistent with US Government R&D funding and will align with PHMSA BAA's and other US based agencies. The EU also generally recognizes the TRL approach utilized by PRCI. To assist those who may be conversant with API 17N the following tabulation shows the API 17N with the PRCI TRL's aligned.



API 17 N Scale (PRCI scale included for reference only)

	TRL (API 17 N)	Development Stage Completed	Definition of Development Stage	TRL PRCI
Concept	0	Unproven Concept (Basic R&D, paper concept)	Basic scientific/engineering principles observed and reported; paper concept; no analysis or testing completed; no design history.	1
Proof-of-Concept	1	Proven Concept (As a paper study or R&D experiments)	a) Technology concept and/or application formulated b) Concept and functionality proven by analysis or reference to features common with/to existing technology c) No design history; essentially a paper study not involving physical models but may include R&D experimentation	2
	2	Validated Concept (experimental proof of concept using physical model tests)	Concept design or novel features of design is validated by a physical model, a system mock up or dummy and functionally tested in a laboratory environment; no design history; no environmental tests; materials testing and reliability testing is performed on key parts or components in a testing laboratory prior to prototype construction	3
Prototype	3	Prototype Tested (System function, performance and reliability tested)	a) Item prototype is built and put through (generic) functional and performance tests; reliability tests are performed including: reliability growth tests, accelerated life tests and robust design development test program in relevant laboratory testing environments; test are carried out without integration into a broader system b) The extent to which application requirements are met are assessed and potential benefits and risks are demonstrated	4
	4	Environment Tested (Pre production system environment tested)	Meets all Requirements of TRL 3; designed and built as production unit (or full scale prototype) and put through its qualification program in simulated environment (e.g. hyperbaric chamber to simulate pressure) or actual intended environment (e.g. subsea environment) but not installed or operating; reliability testing limited to demonstrating that prototype function and performance criteria can be met in the intended operating condition and external environment	5
	5	System Tested (Production system interface tested)	Meets all the requirements of TRL 4; designed and built as production unit (or full scale prototype) and integrated into intended operating system with full interface and functional test but outside the intended field environment	6
Field Qualified	6	System Installed (Production system installed and tested)	Meets all the requirements of TRL 5; production unit (or full scale prototype) built and integrated into intended operating system; full interface and function test program performed in the intended (or closely simulated) environment and operated for less than three years; at TRL 6 new technology equipment might require additional support for the first 12 to 18 months	7
	7	Field Proven (Production system field proven)	Production unit integrated into the intended operating system, installed and operating for more than three years with acceptable reliability, demonstrating low risk of early life failures in the field	8, 9