Leak Tester EtherNet/IP™ Guide

Abstract

This document is to be used by control engineers and other technical personal responsible for communications between programmable logic controllers (PLC's) and the Isaac multi-tester by Z-axis Inc. The document assumes the reader is well acquainted with EtherNet/IP™ as defined by the ODVA association. The reader should also have a good understanding of TCP/IP and UDP/IP protocols.

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Introduction

Welcome

Thank you for your interest in Z-axis's leak tester's. Z-axis's leak testers are high-performance air leak testers with unparalleled test stability and repeatability. Depending on the model, the following tests can be performed: pressure decay, vacuum decay, mass flow, pressure cracking, burst pressure, valve cracking pressure and more. From one to four channels.

General Disclaimer

The User is responsible for determining the suitability of this product for his/her application. The User must ensure that Z-axis's products are installed and used in accordance with all local, state, federal, and private governing bodies and meet all applicable health and safety standards.

Z-axis Inc. has made all reasonable efforts to accurately present the information in the published documentation and shall not be responsible for any incorrect information which may result from unintentional oversights.

Due to continuous product improvements, the product specifications stated in the documentation are subject to change at any time and without notice. The User is responsible for consulting a representative of Z-axis Inc for detailed information and determining any changes of information in the published documentation.

Should Z-axis products be used in an application that is safety critical, the user must provide appropriate safety testing of the products, adequate safety devices, guarding, warning notices, and machine-specific training to protect the operator and/or bystanders from injury.

Communications with Z-axis's leak tester can be accomplished in different ways, RS232, TCP/IP and EtherNet/IP™. This document will describe how to set up EtherNet/IP™ using an Allen-Bradley 5380 CompactLogix Controller. Other types of PLCs can be used if compliant to the EtherNet/IP™ specifications as defined the ODVA association.

EtherNet/IP™ overview

The "IP" in "EtherNet/IP" refers to "Industrial Protocol" and should not be confused with Ethernet, TCP/IP and/or UDP/IP protocols. Although EtherNet/IP™ uses these technologies and protocols to accomplish the desired communications between leak testers and PLCs.

The leak tester firmware consists of different modules, as for EtherNet/IP™ the firmware follows the recommended implementation as defined in the ODVA specifications. See The CIP Networks Library Volume 1 and 2.

The leak testers support both DHCP and static Ethernet configurations. Factory defaults use the following static network configuration:

IP Address	192.168.2.31
Network Mask	255.255.255.0
Gateway	192.168.2.1

Table 1 Factory Default Network Configuration

These defaults can be changed using the leak testers touch screen interface.

Because EtherNet/IP™ relies on TCP/UDP it is necessary that the leak testers and any device wishing to communicate with the testers over Ethernet have the correct network configuration. The network ping command can be used to diagnose network problems etc.

EtherNet/IP™ uses two forms of messaging:

- Unconnected messaging is used to: 1) establish connections, 2) low-priority messages, and 3) infrequent messages. Unconnected messages are handled by the Unconnected Message Manager, e.g., the UCMM software module.
- Connected messaging allocates resources that are dedicated to a particular purpose, such as real-time I/O data transfers. Connection resources are reserved and configured and then allocated to the desired resource.

Connections are created by a Connection Originator (or Originator for short) and the device that responds to the connection request, called the Connection Target (or just Target). In this document the letters O2T indicate messages sent by the originator to the target. The letters T2O indicate messages sent by the target to the originator.

EtherNet/IP™ specifics two types of message connections:

- Explicit message connections are point-to-point relationships. These would be considered general purpose connections and are used to access general information about the leak tester. E.g., revision number, serial number, etc. Explicit messages almost always use TCP/IP connections to communicate.
- Implicit (I/O data) connections are created to communicate application specific I/O data at regular intervals (RPI). Implicit messages use UDP/IP resources to communicate.

The leak tester uses explicit messages to create a connection with other devices (e.g., PLCs etc.) and when requested, creates an implicit connection to periodically return the status of the leak tester. E.g., busy, sequence/state, current program etc.

Both Explicit and Implicit messages have a predefined message structure. The definition for Implicit messages is usually defined by the EDS file. However, these messages structures can be defined manually using user defined data types, while Explicit messages structures must be defined manually.

The EDS file defines three types of messages, often called assemblies. Which are:

- Configuration Assembly. Initial Tester configuration message, which is seldom used. See Configuration Assembly (Instance 0x04) below.
- Output Assembly. Messages sent to the tester from the PLC (O2T). See Output Assembly (Instance 0x02) below.
- Input Assembly. Messages sent to the PLC from the tester (T2O). See Input Assembly (Instance 0x01) below.

For further information and documentation on message types etc. see OVDA publication PUB00138_EtherNetIP_Ethernet_Technology.pdf.

Tester Configuration for EtherNet/IP™

Other than configuring the correct Ethernet (TCP/IP) parameters on the leak tester, no other configuration is required for EtherNet/IP™ communications. Taking note of the tester's IP address, netmask, and gateway (see Table 1 - Factory Default Network Configuration) are required to configure the devices that communicate with the leak tester.

Ensure TCP/IP communications are working by using the ping command to verify communication between the leak tester, the computer and/or the PLC.

PLC Configuration for EtherNet/IP™

The easiest way to start communication with the tester is to consume, or register, the Electron Data Sheet (EDS) file. The EDS file can be downloaded from the tester by putting the IP address of the tester into a Web browser such as Chrome, or Microsoft Edge. For example, http://192.168.2.31 then clicking on the "EtherNet I/O" menu item.

Configuration with the EDS file

Once the EDS file has been downloaded from the tester the EDS file should be registered using Rockwell Automation's EDS Wizard or the applicable tool for the brand of PLC being used. Several resources can be found on the Internet showing the proper procedure to register an EDS file.

Once the tester's EDS file has been registered the configuration can be done as follows:

1. Start Logix Designer and Ensure the Communications are offline. Create a new Ethernet module by right clicking on the **Ethernet** menu item displayed on the Controller Organizer window and select **New Module…** as seen in Figure 1 - New Ethernet Module (EDS) below.

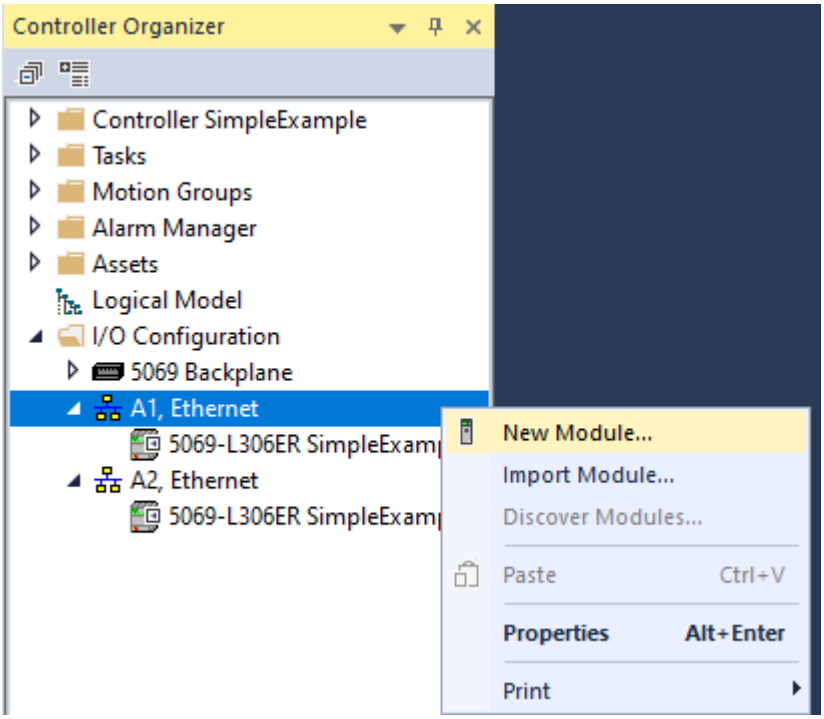


Figure 1 - New Ethernet Module (EDS)

2. The Selecting Module Type window should be displayed Figure 2 - Select Module Type (EDS) as seen below.

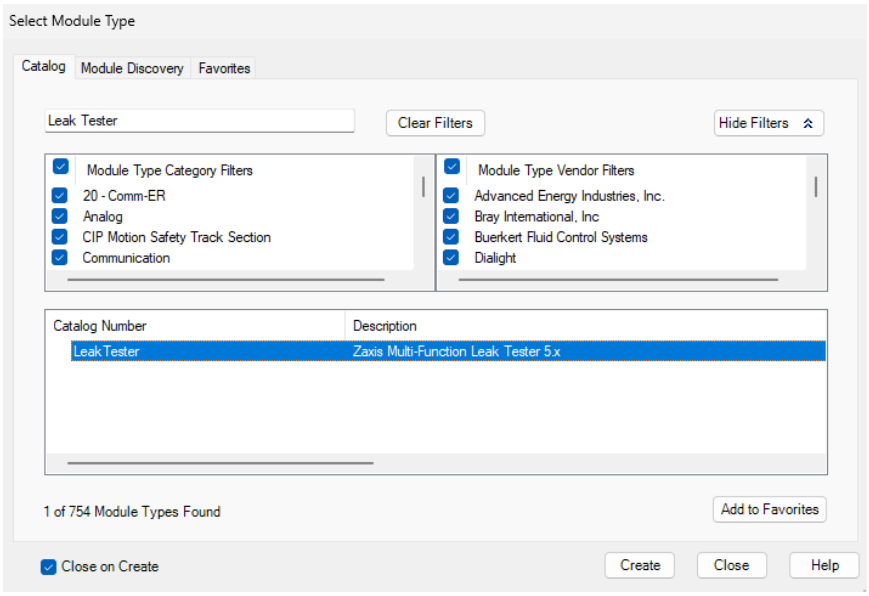


Figure 2 - Select Module Type (EDS)

3. Search for Leak Tester using the Catalog search field to quickly find the Leak Tester module.
4. Click the Create button to create the Leak Tester module, which should display the following window, see Figure 3 below.

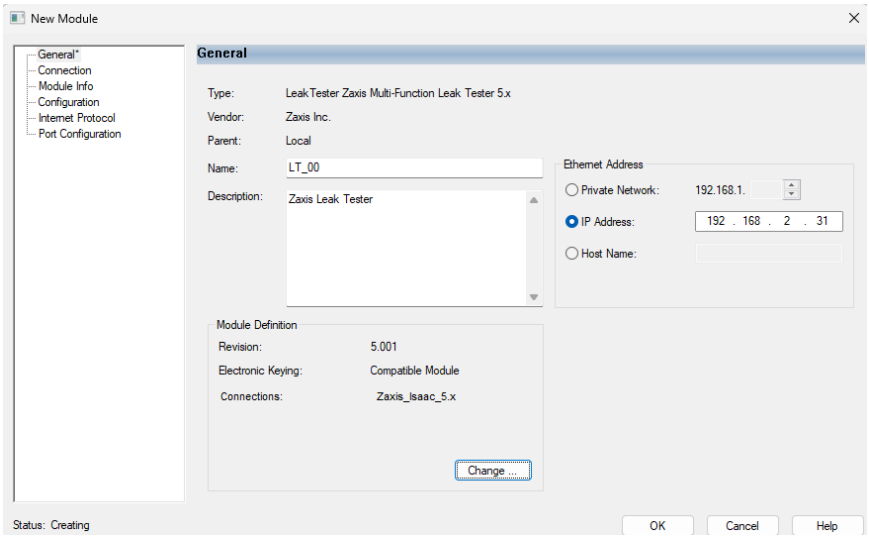


Figure 3 - New Module (EDS)

5. Enter the name for the leak tester (LT_00) and enter the assigned IP address (192.168.2.31).

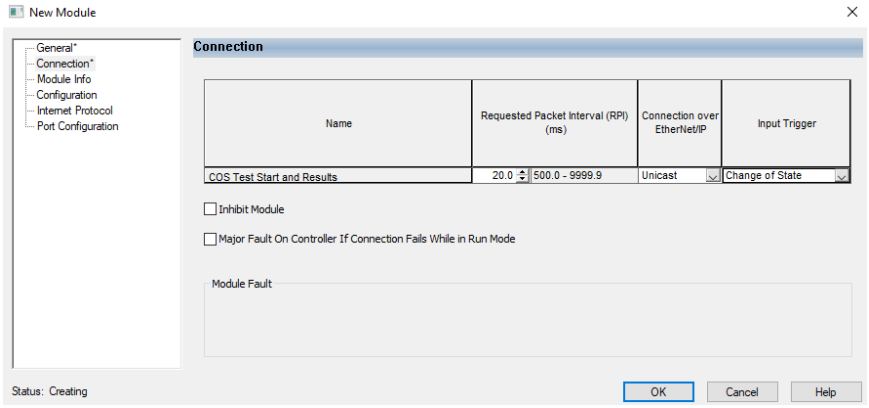


Figure 4 -New Module Connection (EDS)

6. Clicking on the **Connection** menu item will allow changing the type of connection between Change of State and Cyclic. Unless suggested by Z-axis support personnel, it is recommended that the Change of State connection be used. The Connection window allows the Requested Packet Interval (RPI) value to be changed; the default value of 20.0 milliseconds is the recommended value.
7. The Configuration window allows the modification of the EtherNet/IP™ initial parameters. The Configuration parameters are sent to the leak tester whenever the PLC creates an I/O type connection. The Start Mode allows different interlock bits that must be set before the program starts. For more information see the Leak Tester User's Manual, unless suggested by Z-axis support personnel, the default value should be used.

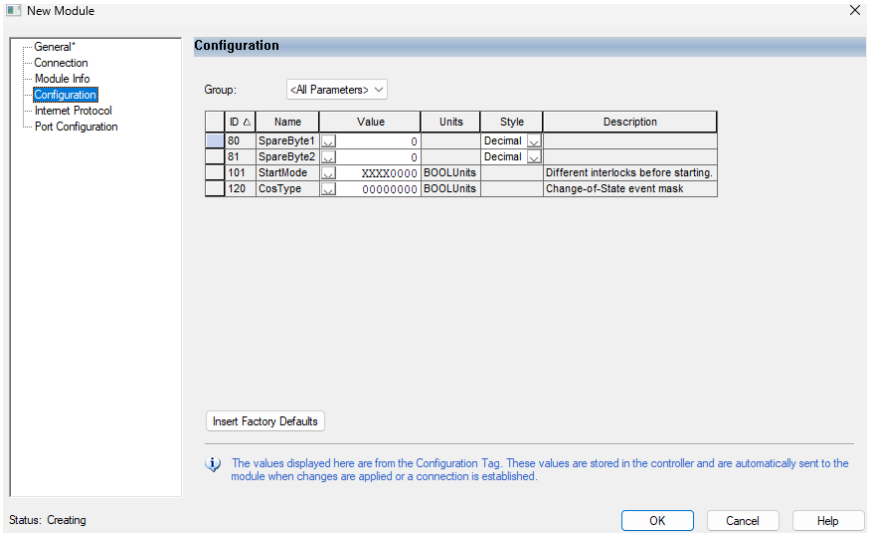


Figure 5 - New Module Configuration (EDS)

8. Clicking the **OK** button will finish the creation of the module, causing the newly created item to appear, as shown below in Figure 6.

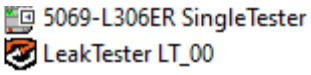


Figure 6 - Leak Tester Module (EDS)

Other module configuration items can be completed by double clicking on the newly created module and setting the desired parameters etc.

Simple Ladder Logic to Start a Test

The following image shows some ladder logic that can be used to start a test on the leak tester.

- Rung 1 ensures the tester isn't currently busy running a test and then starts the test.
- Rung 2 ensures the test has started and then unlatches the start bit.
- Rung 3 waits for the test to finish then determines if the test passed or failed and sets the appropriate pass/fail bit.

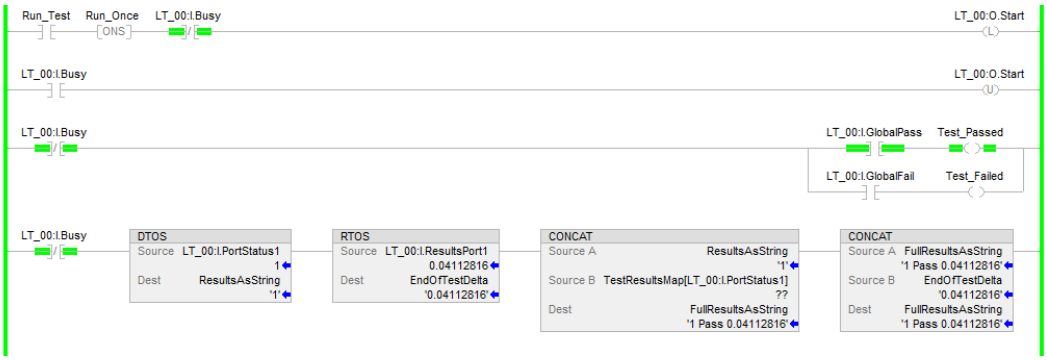


Figure 7 - Start Test Ladder Logic

- Rung 4 is information only, concatenating the different status fields to create a string showing the final test status.
    - First getting the status for port 1 which is "1".
    - Converting port 1's result pressure, e.g., the delta of pressure from the starting of the test step to the end of the test.
    - Mapping the port 1 status of "1" to a string, e.g., Pass
    - Concatenating all the above to produce "1 Pass 0.0411.."

The above ladder logic does not account for any safety procedures and/or communication with multiple leak testers. For example, any type of emergency stop (an abort signal) sent from the PLC.

It is also recommended that all I/O bits be copied, using a CPS instruction, from/to the module's inputs/outputs thus ensuring minimal communication messages and/or timing problems.

Configuration using a Generic Ethernet Module

Configuring the PLC for communications with the leak tester via EtherNet/IP™ consists of creating a new Generic Ethernet Module. Use the following steps.

1. Start Logix Designer and Ensure the Communications are offline.
2. Create a new ETHERNET-MODLE by right clicking on the **Ethernet** menu item displayed on the Controller Organizer window and select **New Module…** which should display the **Select Module Type** window.

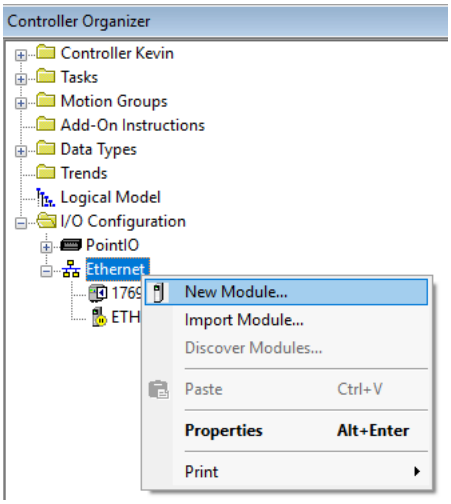


Figure 8 - New Ethernet Module (Generic)

3. In the **Select Module Type** window, use the filter text box to find a **Generic Ethernet Module** as shown below. Then click the **Create** button.

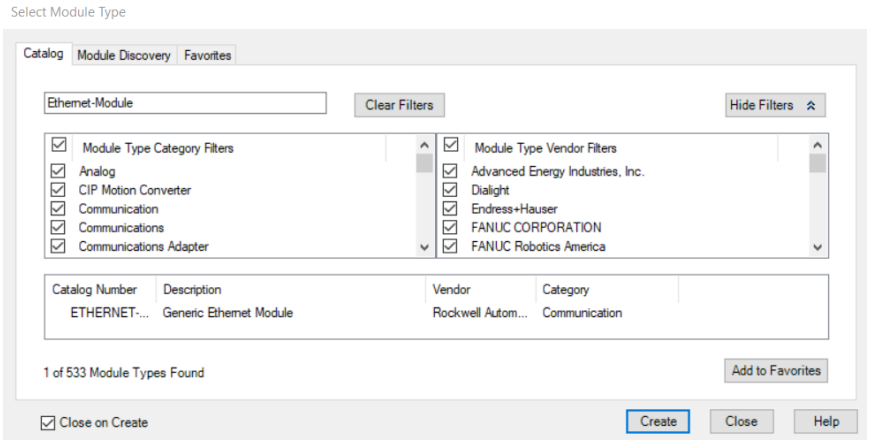


Figure 9 - Select Module Type (Generic)

4. After clicking on the **Create** button the **New Module** information can be entered.
    a. Enter a valid name.

b. Enter a description, if desired.
c. Ensure the **Comm Format** is set to Data – DINT.
d. Enter the **IP address** of the leak tester.
e. Enter **1** for the **Input** Assembly Instance with a Size of 21.
f. Enter **2** for the **Output** Assembly Instance with a Size of 3.
g. Enter **4** for the **Configuration** with a Size of 4 (or **0** if Configuration data is not desired).

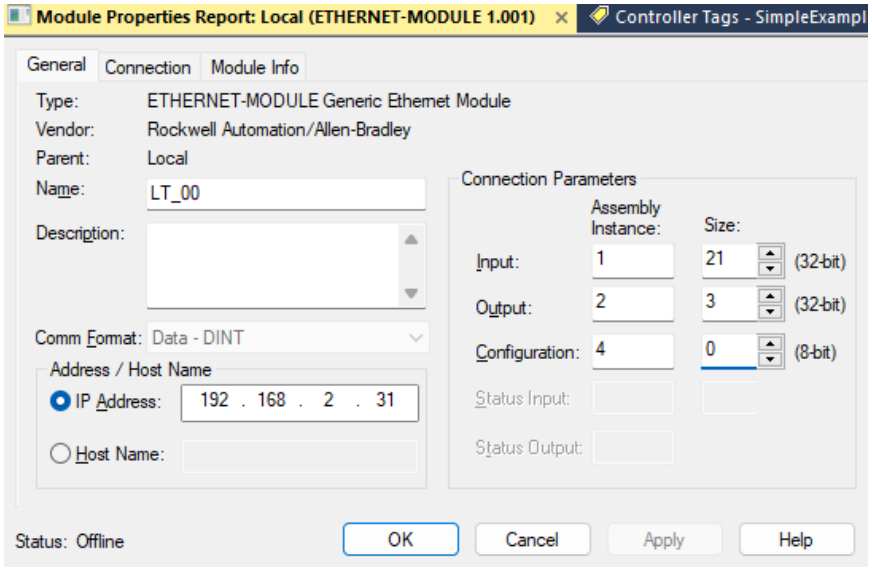


Figure 10 - Module Properties (Generic)

The **Configuration** size is optional, it can be 0 (zero) or 4. When zero, no initial configuration will be done when communications to the leak tester is established. When size is set to 4, a block of 4 bytes will be sent to the tester, used to do initial configuration. See Table 2 - Configuration Assembly below.

5. Clicking the **OK** button creates the new module as well as the necessary controller tags used to interface with the leak tester and displays the **Connection** tab of the newly created module as seen in Figure 11 - Module Connection (Generic) below. Set the **Requested Packet Interval (RPI)** to **20** e.g. 20 milliseconds.

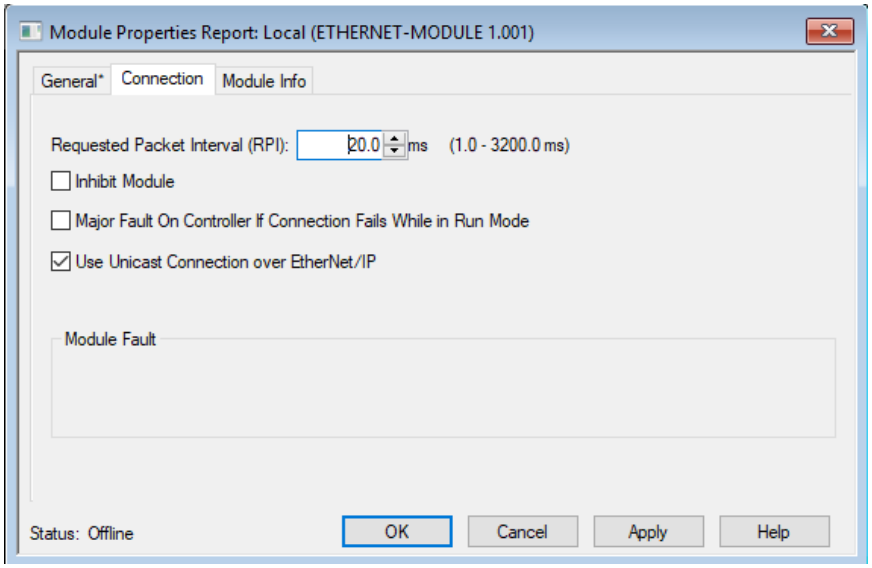


Figure 11 - Module Connection (Generic)

6. Click the **Apply** button to save the properties of the newly created module.
7. Open the **Controller Tags** menu item to display the newly created tags for the leak tester module as shown in Figure 11. E.g. the LT_00:C, LT_00:I, LT_00:O tags.

LT_00:C			AB:ETHERNET_MODULE:C:0	Read/Write
LT_00:C.Data			SINT[400]	Read/Write
LT_00:I			AB:ETHERNET_MODULE_DINT_84Bytes:I:0	Read/Write
LT_00:I.Data			DINT[21]	Read/Write
LT_00:O			AB:ETHERNET_MODULE_DINT_12Bytes:O:0	Read/Write
LT_00:O.Data			DINT[3]	Read/Write

Figure 12 - Module Connections Tags (Generic)

Leak Tester Object Modules

The following tables and comments describe the different object modules available on the Z-axis leak tester.

The following three assemblies are automatically created when the Z-axis EDS file has been registered on the PLC.

1. Configuration Assembly (Instance 0x04)
2. Output Assembly (Instance 0x02)
3. Input Assembly (Instance 0x01)

The above assemblies provide the necessary objects allowing Implicit (I/O) messages between the PLC and the tester.

Configuration Assembly (Instance 0x04)

The configuration assembly is optional and is not required for I/O messages to be transmitted/received between the tester and the PLC. If a length of zero (0) is specified in the connection parameters, the configuration assembly data is not used.

If a length other than zero is specified in the connection parameters, then the configuration data is transmitted to the tester whenever a connection is established. Currently the only significant data in the configuration assembly is the definition of the inputs required to start a test on the tester. The default is zero, meaning only the start bit/button is required to start a test.

Name	Data Type	Valid Values	Description
StartMode	SINT	0 thru 7	Start Test: 0 = start button, 1 = input 1, 2 = input 1 & 2, 4 = input 1 & start button, 8 = UserIdTimeOut
CosEvent	SINT	0 to 0xFF	Indicates which change-of-states events should be reported. Should be set to 0.
Spare2	SINT	0	Spare data
Spare3	SINT	0	Spare data

Table 2 - Configuration Assembly

The StartMode bit mask determines which discrete input signals need to be asserted for a test to start. Thus, allowing different interlocks for safety and/or tooling to be in place before a test starts.

For example, if StartMode is set to 2 then both discrete input bits 1 and 2 (Anti-Tie input bit) must be high before the test can be started.

The CosEvent flags are used to indicate which change-of-state events will cause an unsolicited message to be sent to the PLC. Currently this should be set to zero unless instructed otherwise by a Z-axis employee.

Output Assembly (Instance 0x02)

The output assembly is sent to the leak tester, e.g., from the PLC to the leak tester every RPI (request packet interval) milli-seconds. Whenever the output assembly is received by the leak tester, the Input Assembly is sent back to the sender of the output assembly. The following table shows the structure of the output assembly.

Name	Data Type	Valid Values	Description
Start	BOOL	0 or 1	Bit 0 = Start a test
Abort	BOOL	0 or 1	Bit 1 = Stop the current test
SpareBit	BOOL	0 or 1	Bit 2 = Spare bit
IgnoreCmds	BOOL	0 or 1	Bit 3 = Ignore EtherNet IP commands
LeakStandard	BOOL	0 or 1	Bit 4 = Use Leak Standard valve on next test start
ValvesOnOff	BOOL	0 or 1	Bit 5 = Turn on/off valves according to ValveOnOfMask. Used for testing valves only.
SetProgram	BOOL	0 or 1	Bit 6 = Change program to value in ProgramNumber
ProgramNumber	SINT	0 thru 99	Program to use when SetProgram bit is set.
SpareByte1	SINT	N/A	Spare data
ValvesOnOffMask	INT	0 to 0xFF	Bit mask of valves to turn on/off when ValvesOnOff bit is set. Should be set to zero for production.
SpareDInt1	DINT	N/A	Spare data

Table 3 - Output Assembly Tags

Output Assembly Tag Description

Start bit

This bit performs the same function as the green button on the front of the leak tester. E.g., when transitioning from a low to a high if the tester is not already running a test a test will be started.

Abort bit

This bit performs the same function as the red button on the front of the leak tester. E.g., abort any currently running test.

IgnoreCmds bit

This bit causes all commands except the Abort command, contained in the output assembly, to be ignored. Useful when debugging PLC ladder logic, etc.

LeakStandard bit

Setting this bit turns on the leak standard valve which allows a leak standard device to be used for the test.

ValvesOnOff bit and ValvesOnOffMask

Setting this bit causes the value in ValvesOnOffMask to be used as a bit mask to turn off/on the indicated valves. E.g., if bit zero is on, valve 1 will be turned on. This should ONLY be used for testing

valves and debugging. This bit should always be zero and the ValvesOnOffMask should always be zero when running in production mode.

SetProgram bit and ProgramNumber

Setting the SetProgram bit causes the number found in ProgramNumber to become the current program. If ProgramNumber contains an invalid number e.g., less than zero or greater than 99, no action is taken, and the currently active program is used.

Input Assembly (Instance 0x01)

Input tags are sent to the PLC from the leak tester after the Output tags have been scanned, or processed, by the leak tester. The input assembly provides the current state of the leak tester. The following table lists the tags found in the input assembly.

Name	Data Type	Valid Values	Description
CosEvent	INT	0 or 1	See Input Assembly Tag Description COSEvent Change-of-State Event bits. Used by Z-axis.
ProgramNumber	SINT	0 thru 99	Current program
Step	SINT	0 thru 14	Current step/sequence.
TestType	SINT	0 thru 18	Type of test being run.
ChannelsEnabled	SINT	0 thru 15	Bit mask of enabled channels.
ValveMask	SINT	0 thru 15	Bit mask of current valves on/off.
SpareByte1	SINT	0	Spare data
SpareByte2	SINT	0	Spare data
StatusPort1	SINT	0 thru 24	Status of port 1
StatusPort2	SINT	0 thru 24	Status of port 2
StatusPort3	SINT	0 thru 24	Status of port 3
StatusPort4	SINT	0 thru 24	Status or port 4
SpareInt1	INT	0	Spare data
SpareInt2	INT	0	Spare data
FlagsStatus	DINT	0 or more	Status bit mask
ElapseTime	FLOAT	0 or more	Sequence/step elapse time in 1/10 seconds.
PressurePort1	FLOAT		Port 1 pressure
PressurePort2	FLOAT		Port 2 pressure
PressurePort3	FLOAT		Port 3 pressure
PressurePort4	FLOAT		Port 4 pressure
ResultsPort1	FLOAT		Pressure delta or crack pressure etc. on port 1
ResultsPort1	FLOAT		Pressure delta or crack pressure etc. on port 2
ResultsPort1	FLOAT		Pressure delta or crack pressure etc. on port 3
ResultsPort1	FLOAT		Pressure delta or crack pressure etc. on port 4
FlowPort1	FLOAT		Flow on port 1
FlowPort2	FLOAT		Flow on port 2
FlowPort3	FLOAT		Flow on port 3
FlowPort4	FLOAT		Flow on port 4
SpareFloat1	FLOAT	0	Spare data

SpareFloat2	FLOAT	0	Spare data

Table 4 - Input Tage

Input Assembly Tag Description

COSEvent Change-of-State Event bits

Change-of-state bits indicate to the originator (e.g., usually the PLC) why a message was sent from the tester. Allowing the PLC (or originator). For example, when the CosTestResults bit is set the values in the TestResults fields are valid end of test results.

ProgramNumber

The current program number 00 through 99 that is running.

Step

Current test step (or sequence step) being run. See

Test Step below.

TestType

Type of test being run. See Test Types below

ChannelsEnabled

Bit mask indicating which channels are currently enabled 0x1 through 0xFF.

ValveMask

The valve mask field indicates which valves are on/off, 1 indicating on and 0 off. The mask changes based on the current type of test being run and/or the current valve configuration. However, the standard masks are given below. Contact Z-axis support to confirm the valve masks for your Leak testers. See Valve Mask below.

StatusPort 1 to 4

Current stats of the given port. See Channel/Port Status below.

FlagsStatus

Bit masks indicating the status of the tester see Status Flags below.

ElapseTime

The amount of time spent in the current test step in 1/10 seconds increments.

PressurePort 1 to 4

Current pressure reading for the given port.

ResultsPort 1 to 4

The last test results of the given port. See Channel/Port Status below.

FlowPort 1 to 4

Current flow reading for the given port.

Leak Tester Configuration Object (Class 0x64)

Configuration parameters are those parameters that remain the same regardless of which program (or test) is being executed. Configuration parameters are typically set once on initial configuration at the Z-axis office, and very seldom changed.

Attribute Number	Name	Data Type	Valid Values	Description
1	CosEvent	SINT	Read Only	Change-of-State event flags
2	DataLogging	SINT	0, 1, 2	0=Off, 1=Results Only, 2=Detailed
3	PressureUnits	SINT	1 thru 7	psig, mbar, mmHg, etc.
4	FlowUnits	SINT	1 or 2	1=sccm, 2=slm
5	TestPresDigits	SINT	0 thru 3	Number of digits in test pressures
6	ResultsPresDigits	SINT	0 thru 5	Number of digits in results pressure
7	FlowPresDigits	SINT	Read Only	Number of digits in flow values
8	Bcd	SINT	0 thru 7	BCD Inputs
9	NumberChans	SINT	Read Only	Configured number of channels
10	SensorsPressure	SINT	Read Only	Number of installed pressure sensors
11	SensorsFlow	SINT	Read Only	Number of installed flow sensors
12	StartMode	SINT	1, 2, 4 or 8	Input bits required for starting test
13	SpareByte1	SINT	Read Only	Spare data position
14	SpareByte2	SINT	Read Only	Spare data position
15	SpareInt1	INT	Read Only	Spare data position
16	SpareInt2	INT	Read Only	Spare data position
17	CfgFlags	DINT	Bit mask	Bool configuration flags
18	AvailTestTypes	DINT	Read Only	Bit mask of available types of tests.
19	BaudRate	DINT	See below	Baud rate for Serial port.
20	FilterPress	DINT	0 to 5,000	Pressure filter cutoff
21	FilterFlow	DINT	0 to 5,000	Flow filter cutoff
22	FilterFillSettle	DINT	0 to 5,000	Settle filter cutoff
23	IoResetTime	FLOAT	0 to 3,000	Milliseconds output is latched
24	HighBleedPressure	FLOAT	0 to 30,000	High bleed pressure
25	AtmosphericPress	FLOAT	0 thru 16	Atmospheric Pressure
26	SpareDint1	DINT	Read Only	Spare data position
27	SpareDint2	DINT	Read Only	Spare data position
28	SerialNumber	String	Read Only	Tester serial number
29	IpAddress	String	Valid IP	IP address of the tester
30	IpNetmask	String	IP mask	IP network mask
31	IpGateway	String	IP Gateway	IP gateway address
32	MacAddress	String	Read Only	Device MAC address
33	DateTime	String	Date & time	YYYY-MM-DD hh:mm:ss

Table 5 - Configuration Parameters

Configuration Object Tag Description

COSEvent Change-of-State Event bits

See Input Assembly Tag Description

COSEvent Change-of-State Event bits above.

DataLogging

Determines the messages that are logged to a USB thumb drive, Ethernet port 23, and local disk or historical data. See Data Logging Flags below under Definitions.
Note: Only test results are logging to the "historical" device, e.g., the local disk or a SSD to avoid filling the local disk.

PressureUnit

Units that pressure readings are displayed in. See Pressure Units below under Definitions.

FlowUnits

Units that flow reading are displayed in. See Flow Units below under Definitions.

TestPresDigits

Number of numeric digits to display after the whole number for test pressures.
0 through 3.

ResultsPresDigits

Number of numeric digits to display after the whole number for test results pressures.
0 through 5.

FlowPresDigits

Number of numeric digits to display after the whole number for flow pressures.
0 through 3.

Bcd

Binary-coded decimal bits for the program number to use when using digital inputs.
Valid only when the I/O module is installed.

NumberChans

Number of hardware configured channels or ports in the tester. 1 through 4, read only.

SensorsPressure

Number of pressure sensors installed. 1 through 4, read only.

SensorsFlow

Number of flow sensors installed. 0 through 4, read only

StartMode

Flags indicate which digital inputs must be set before a test starts.
There are three options for test start.

Start on Input 1: Activating input 1 on the I/O connection will start the cycle. The input starts the test on the rising edge of the signal. This selection is the default and allows the start button or input 1 on the I/O module to initiate the test.

Start on Input 1&2 (Anti-tie): This option is used when an operator needs to be clear of movement in the fixture. Two separate switches must be contacted within 300msec of each other, one switch cannot be held closed while the other is triggered.

Start on Input 1 & Start Button (Interlock): This option has a condition to be met before the test can proceed. Input 1 on the I/O connector must be held active before the START button is pressed. If the input is released before the test ends, the test will be aborted. A typical application would be for a door switch on a safety enclosure.

UserIdTimedout: This option has a condition that a User Id must be reentered before a test can be started. E.g., the User Id has timed out and needs to be refreshed.

CfgFlags

Bool flags indicating different configurations. See Config Flags below under Definitions.

AvailTestTypes

Bit mask indicating which test types are configured and available on the leak tester. See Available Test Types below under Definitions.

BaudRate

Value indicating the baud rate of the RS232 port. Valid values are: 9600, 19200, 57600, 115200, and 230400.

FilterPress

Pressure filter cutoff value.

FilterFlow

Flow filter cutoff value.

FilterFillSettle

Settle filter cutoff value.

IoResetTime

Time in milliseconds to latch the digital output signal.

HighBleedPressure

High bleed limit pressure.

AtmosphericPress
Value of the atmosphere pressure. Default is 14.7 psi.

SerialNumber
Serial number of the tester. Up to 16 characters.

IpAddress
Current network IP address of the tester.

IpNetmask
Current network Netmask of the tester.

IpGateway
Current network Gateway of the tester.

MacAddress
Current network MAC address. Read only.

DateTime
Current date and time of the testers. The format is yyyy-MM-dd hh:mm:ss

Reading and Writing of Configuration Parameters
Each configuration parameter can be read/written using the CIP Get/Set Attribute Single service (service numbers 0x0E = 14 and 0x10 = 16).

Using the Molex EtherNet/IP tool to write the number of digits in the results pressure (attribute 6) from the configuration object 1 (Instance 1) and Class 0x64 (the configuration class/object).

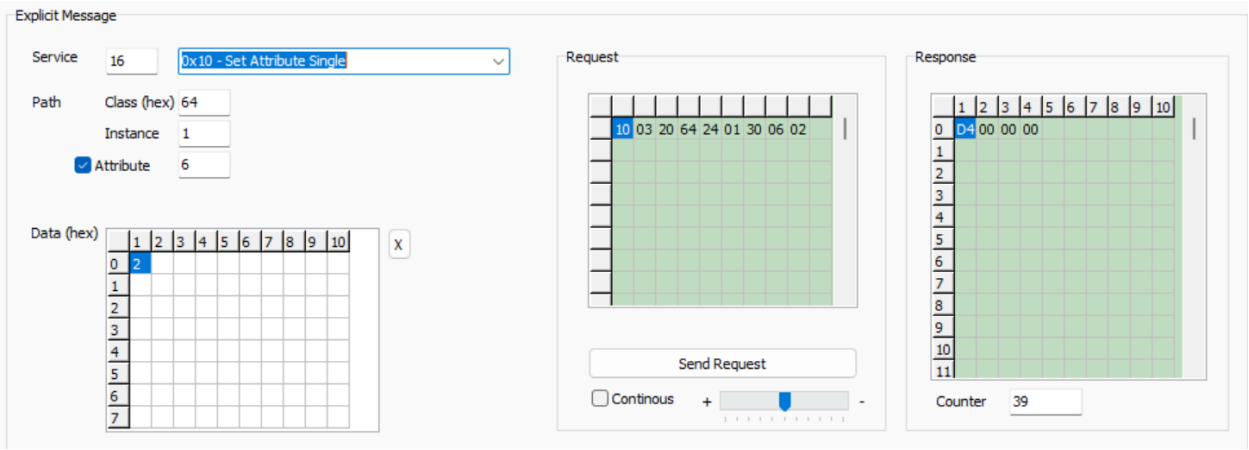


Figure 13 - Set Attribute Single

The response shown above consists of a four-byte header (D4, 00, 00, 00).

Reading the same value is shown below.

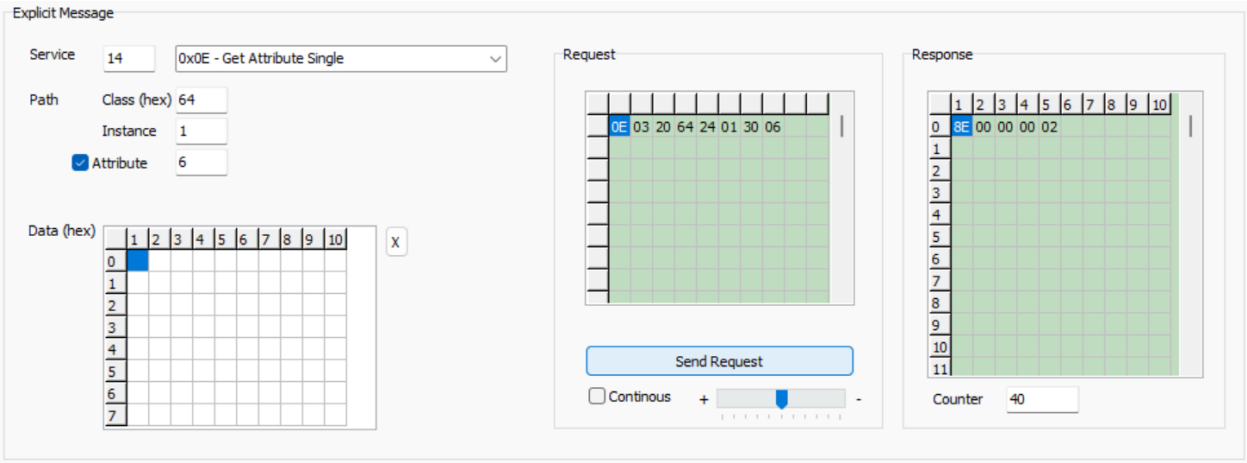


Figure 14 - Get Attribute Single

The response shows a four-byte header (8E, 00, 00, 00) and single byte (SINT) value of 2.

The Get/Set Attributes All (service number 0x01 and 0x02) can also be used to read/write all the parameters at once. Below all the configuration parameters are read at once.

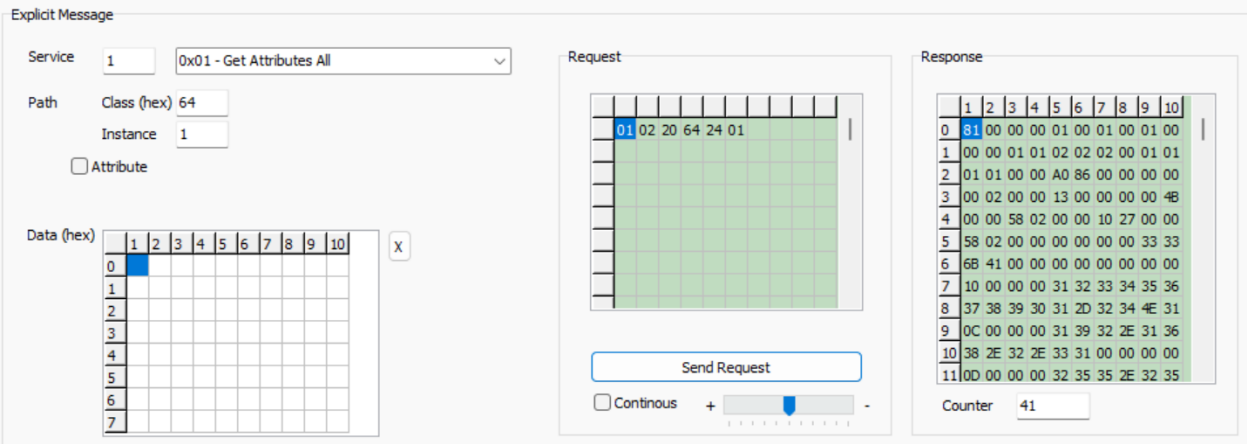


Figure 15 - Get Attributes All

When all the parameters are read/written an object struct can be used, often called a User-Defined Type (e.g., UDT). An Excel spreadsheet (LeakTester_Utds.xlsx) can be downloaded from the Leak tester by browsing to the IP address of the tester. E.g., http://192.168.2.31.

Leak Tester Program Object (Class 0x65)

Program parameters allow the Isaac tester to be configured such that different programs, loops or tests can be run by the same tester yet perform completely different tasks. Programs can be linked allowing one program to execute after the parent program, with each program having different parameters. Table 6 shows the different program parameters and their meaning.

Note: All time parameters (e.g., TimeClampX, TimeFill, etc.) are in hundreds of seconds. i.e., 0.01 seconds would be returned as 1, and 1.23 seconds would return a 123.

Attribute Number	Name	Data Type	Valid Values	Description
1	CosEvent	SINT	Read Only	Change-of-State event flags
2	ProgramNumber	SINT	Read Only	Program number 0 thru 99
3	NextProgram	SINT	0 thru 99	Next program to run.
4	TestType	SINT	0 thru 18	Type of test to run see below.
5	ChannelsEnabled	SINT	1 thru 15	Enabled channels bit mask
6	ClampDuringTest	SINT	0 thru 15	Clamps on during test bit mask
7	SpareByte1	SINT	0	Spare data position
8	PreFillMode	SINT	0, 1 or 2	Pre-fill Mode. 0=Timed, 1=Ramp, 2=Auto
9	AdjustPercentage	SINT	0 to 100	Percentage of fill for Elect Reg
10	SpareByte2	SINT	0	Spare data position
11	Loops	INT	0 or more	Run the program loop times.
12	Rpm	INT	0 or more	Currently not used
13	TimeIdle	INT	0 or more	Not used. Place holder
14	TimeClamp1	INT	0 or more	Time to spend in 1st clamp step
15	TimeClamp2	INT	0 or more	Time to spend in 2nd clamp step
16	TimeClamp3	INT	0 or more	Time to spend in 3rd clamp step
17	TimeClamp4	INT	0 or more	Time to spend in 4th clamp step
18	TimePreFill	INT	0 or more	Time to spend in prefill step
19	TimeFill	INT	0 or more	Time to spend in Fill step
20	TimeSettle	INT	0 or more	Time to spend in Settle step
21	TimeTest	INT	0 or more	Time to spend in Test step.
22	TimeVent	INT	0 or more	Time to spend in Vent step
23	TimeCustom	INT	0 or more	Time to spend in Custom step
24	TimeUnClamp4	INT	0 or more	Time to spend in 4th unclamp step
25	TimeUnClamp3	INT	0 or more	Time to spend in 3rd unclamp step
26	TimeUnClamp2	INT	0 or more	Time to spend in 2nd unclamp step
27	TimeUnClamp1	INT	0 or more	Time to spend in 1st unclamp step
28	SpareShort1	INT	0	Spare data position
29	Flags	DINT	0 thru 127	Set/clear program flags
30	SpareInt1	DINT	0	Spare data position
31	TestPressure	FLOAT	0 or more	Test pressure
32	TestPressureMin	FLOAT	0 or more	Min. Test pressure
33	TestPressureMax	FLOAT	0 or more	Max. Test pressure
34	PreFillPressure	FLOAT	0 or more	Pre-Fill pressure

35	IncreaseLimit	FLOAT	0 or more	Increase Limit
36	Decay	FLOAT	0 or more	Press Decay
37	MaxLimit	FLOAT	0 or more	Min Test Press Tolerance
38	MinLimit	FLOAT	0 or more	Min Test Press Tolerance
39	Trigger	FLOAT	0 or more	Burst trigger
40	RampRate	FLOAT	0 or more	Rate of burst ramp
41	Volume	FLOAT	0 or more	Flow volume
42	Distance	FLOAT	0 or more	Increase Limit
43	RegKp	FLOAT	0 to 10,000	Elect. Reg. Kp
44	RegKi	FLOAT	0 to 10,000	Elect. Reg. Ki
45	SpareFloat1	FLOAT	0	Spare data position
46	SpareFloat2	FLOAT	0	Spare data position
47	ProgramName	String	ASCII	Program Name

Table 6 - Program Object

Z-Span Additional Attributes

When the Z-Span option is enabled the program object has the following overlapping/additional attributes.

Attribute Number	Name	Data Type	Valid Values	Description
45	ClampMax	FLOAT	0 or more	Maximum clamp pressure
46	ClampMin	FLOAT	0 or more	Minimum clamp pressure
47	ClampTarget	FLOAT	0 or more	Desired clamp pressure
48	ZNull	FLOAT	0 or more	Run ZSpan Null get test
49	ZSpan	FLOAT	0 or more	Run Zspan get test
50	ZLeakStandard	FLOAT	0 or more	Run Zspan with leak standard
51	SpareFloat1	FLOAT	0	Spare data position
52	SpareFloat2	FLOAT	0	Spare data position
53	SpareFloat3	FLOAT	0	Spare data position
54	ProramName	String	ASCII	Program Name

Table 7 - Additional Z-Span attributes

Program Object Tag Description

COSEvent Change-of-State Event bits

See Input Assembly Tag Description

COSEvent Change-of-State Event bits above.

ProgramNumber

The current program number 00 through 99 that is running.

NextProgram

The next program too run as a part of the test if this number is different than the program number.

TestType
Type of test to run. See Test Types below under Definitions.

ChannelsEnabled
Bit mask of enabled channels for this program. 1 through 4.

ClampDurningTest
Bit mask indicating which clamps e.g., output bits to set during the test.

PreFillMode
Prefill mode: 0 = Timed, 1 = Ramp, 3 = Auto.

AdjustPrecentage
Percentage fill for the electronic regulator.

Loops
Number of times to run the current program. Zero is the same as 1.

Rpm
Currently not being used.

TimeIdle
Place holder for how long the tester is in the idle step.

TimeClamp 1 to 4
The amount of time to spend in the clamp step 1 through 4, in hundreds of seconds.

Time Pre-Fill, Fill, Settle, Test and Vent
The amount of time to elapse within each step. Given in hundreds of seconds.

TimeCustom
The amount of time to elapse within the custom step. Given in hundreds of seconds.

TimeUnClamp 1 to 4
The amount of time to spend in the un-clamp 1 through 4, in hundreds of seconds.

Flags
Boolean program flags that can be OR 'ed together to change the behavior of the test. See Program Flags below under Definitions.

TestPressure
Pressure at which to start the test.

TestPressure Min and Max
Minimum and maximum pressure allow for the test to complete successfully.

PreFillPressure
Pressure at which to fill the part before the test starts.

IncreaseLimit
Pressure allowed to go to before the test starts.

Decay
The amount of pressure decay allowed for the test.

Max and Min Limit
Upper and lower limits for a break/burst type test.

Trigger
Pressure at which the part should burst for a burst type test.

RampRate
Rate of burst ramp.

Volume
Flow volume allowed for flow type testes.

Distance
Custom value when a syringe is being used.

Reg Kp and Ki
Percentage of feedback for the electronic regulator.

ProgramName
The name of the program, up to 16 ASCII characters.

Reading and Writing of Program Parameters
Each program parameter can be read and written using the CIP Get/Set Attribute Single service (service numbers 0x0E = 14 and 0x10 = 16).

Using the Molex EtherNet/IP tool to read the current Test Time (attribute 21) from program 1 (Instance 1) and Class 0x65 (the Program class/object)

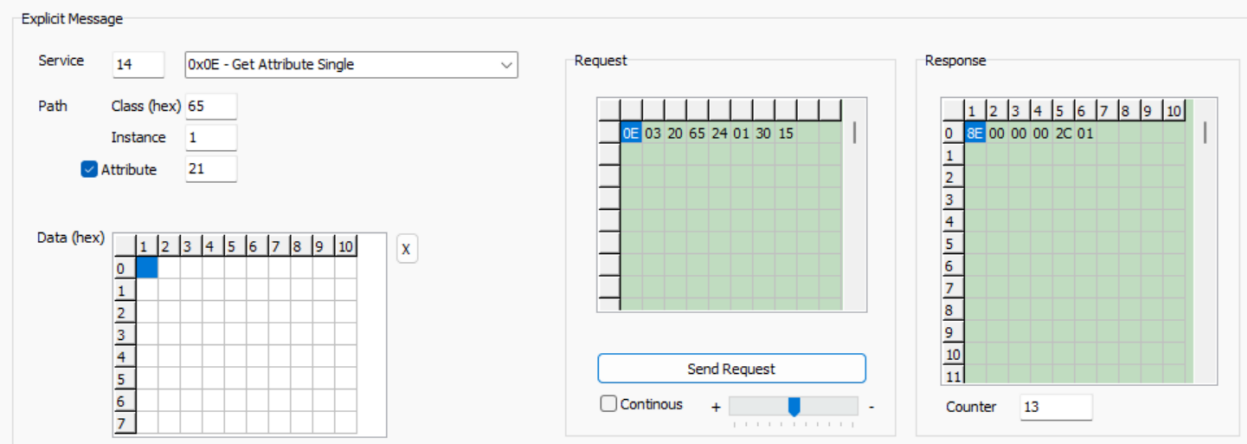


Figure 16 - Program Get Attribute Single

The response is 2C 01 which is equivalent to 300. Indicating the test time is 3.00 seconds.

Reading and Writing classes/objects with an Allen-Bradley PLC

Configuration and program parameters can be read and written using the PLC Message (MSG) instruction. The only difference between reading and writing the different objects are the parameters used e.g., class, instance and attribute.

The following ladder logic can be used as an example.

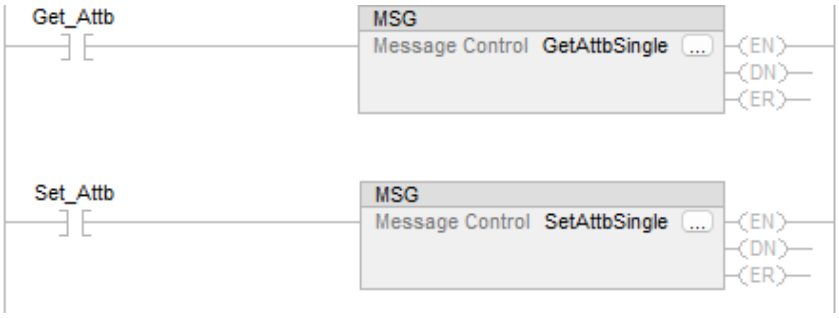


Figure 17 - Reading/Writing classes/objects

Configuration/Program parameters are read/written using the CIP Read/Write Attributes message. These CIP messages (Read/Write Attributes All/Single) are created on the PLC using the *CIP Generic Message Type*.

The following list shows the required parameters for the MSG tag.

- **Service Code**:
  - 0x1 = Read all attributes
  - 0x2 = Write all attributes
  - 0xE = Get attribute single
  - 0x10 = Set attribute single
- **Class**:
  - 0x65 = Program object/class
  - 0x64 = Configuration object/class
- **Instance**:
  - 1 = Configuration only has one instance.
  - 0 through 99 = Program instance, e.g., program number.
- **Destination Element** should be a *User-Defined* data type which minors the tags described above in Table 5 - Configuration Parameters or Table 6 – Program.

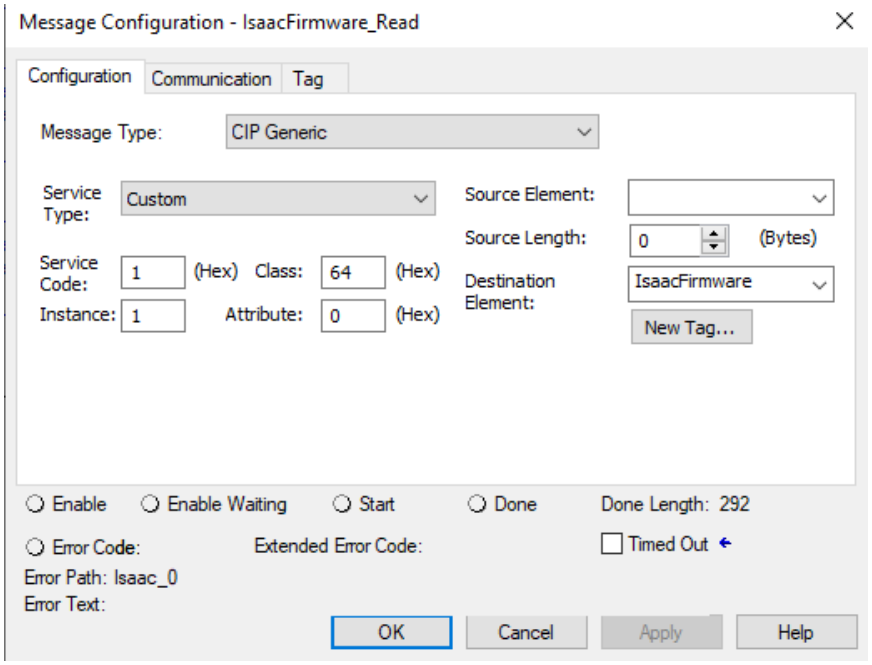


Figure 18 - MSG Tag Configuration

The *Communication* tab references the **Path** of the Leak tester Ethernet module.

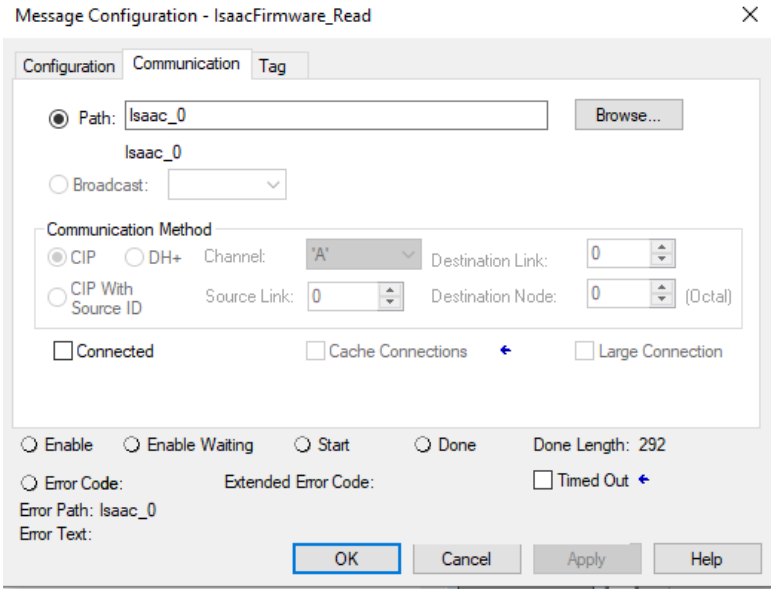
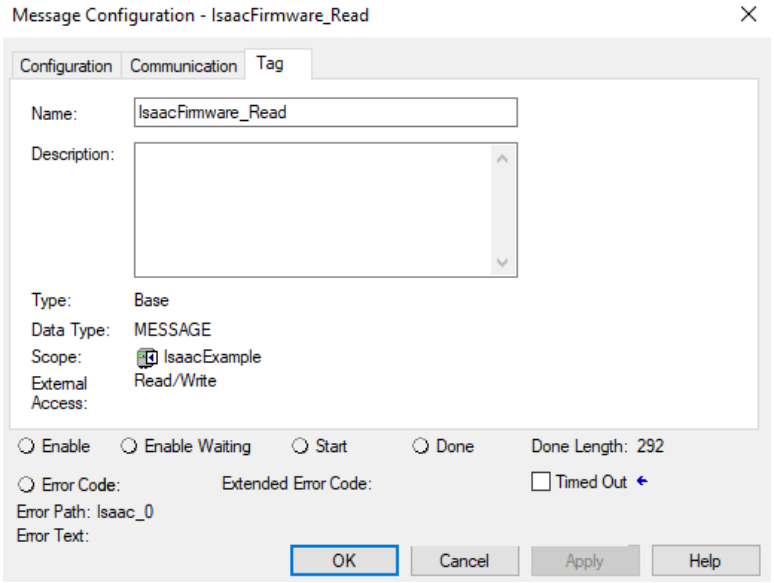


Figure 19 -MSG Tag Communication

The MSG Tag can be given any meaningful name as shown below to complete the configuration.



Reuse of the MSG tag

The MSG tag can be reused to configure multiple Leak testes following the examples shown in the "Logix 5000 Controllers Message Programming Manual" created by Rockwell automation. See https://literature.rockwellautomation.com/idc/groups/literature/documents/pm/1756-pm012_-en-p.pdf Chapter 3 for more information.

Trouble Shooting

When problems occur, either in setting up the communications, or communicating with the Tester, sometimes it is helpful to get more information than a simple fault error. Two different web pages can be accessed to help resolve errors. Both can be found by pointing your web browser to the IP address of the tester. Doing so, you should see a screen like the following:

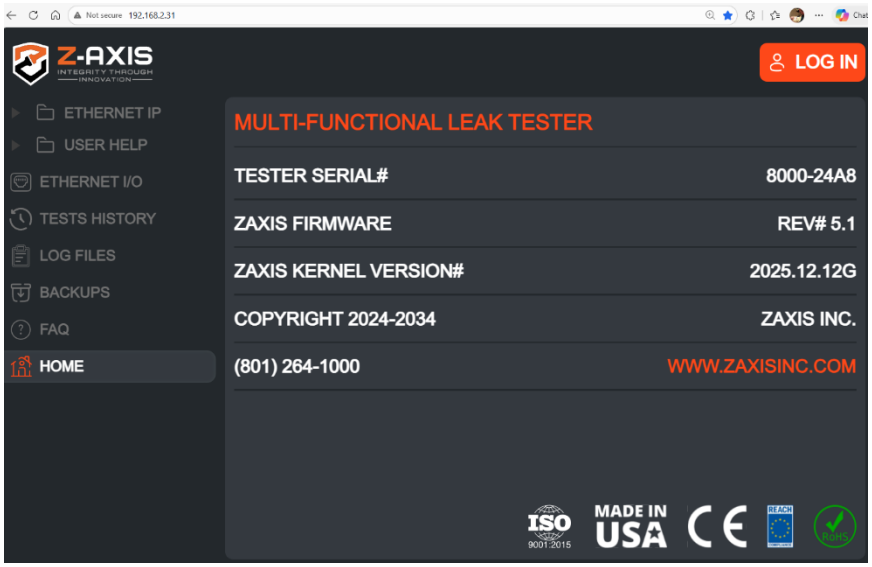


Figure 20 - Display EtherNet I/O messages

Selecting **EtherNet I/O** menu item will display a web page that shows all I/O messages between the Leak tester and the PLC.

Error Codes Generated by the Tester

The following table lists the different error codes that can be returned from the Isaac tester. This table (General Status Codes) indicates the overall success/failure of the given request. These codes are defined by Common Industrial Protocol (CIP). Typically, these codes are displayed by the PLC.

General Status Codes

Numeric Status Code	Status Code Name	Description
0x00	Success	Service was successfully performed by the specified object.
0x01	Communications Related Problem	A communications subsystem related problem was detected along the communications path.
0x03	Invalid parameter value	A parameter associated with the request was invalid. Such as an invalid instance id, invalid IP address, invalid encapsulation parameter,
0x04	Path segment error	The path segment identifier or the segment syntax was not understood by the Isaac.
0x06	Partial transfer	Only part of the expected data was transferred.

0x08	Service not supported	The requested service was not implemented or was not defined for this Object Class/Instance.
0x0C	Object state conflict	The object cannot perform the requested service in its current mode/state. Usually occurs when a calibration command is sent but the Isaac is not in calibration mode.
0x13	Not enough data	The service did not supply enough data to perform the specified operation. Typically caused by an invalid Assembly size.
0x14	Attribute not supported	The attribute specified in the request is not supported. Typically caused by an invalid Assembly size.
0x15	Too much data	The service supplied more data than was expected.
0x16	Object instance does not exist	The object instance specified does not exist in the device.
0x1A	Routing failure, request packet too large	The service request packet was too large. Typically caused by an invalid Assembly size.
0x1F	Vendor specific error	This occurs when the Isaac fails to resolve an IP address in the ARP cache. This indicates a slow or faulty hub/switch.
0x25	Key Failure in path	The Key Segment that was included as the first segment in the path does not match the destination module.
0x2E	Service Not Supported for Specified Path	The object supports the service, but not for the designated application path (e.g. attribute).

Table 8 - General Status Codes

This second table (Encapsulation Status Codes) is a part of the EtherNet IP encapsulation header. Generally, these codes are not displayed by a PLC but can be seen when using a network analyzer such as Wireshark.

Encapsulation Status Codes

Numeric Status Code	Status Code Name	Description
0x00	Success	Service was successfully performed by the specified object.
0x01	Invalid Command	An invalid or unsupported EtherNet IP encapsulation command was received. A command other than: List Services, List Identity, List Interfaces, Register Session, Unregister Session, Send RR data request or Send Unit Data was received.
0x64	Invalid Session Handle	An incorrect session handle was given when registering an EtherNet IP session.
0x65	Invalid Length	The length of the encapsulation header was invalid.
0x69	Unsupported Protocol	A protocol version other than 1 was given in the EtherNet IP encapsulation header.

Table 9 - Encapsulation Status Codes

Definitions

Change-of-State Event mask bits

Change-of-Event bits mask bits indicate the reason the tester sent a message to the originator (usually the PLC). These bits are used by Z-axis Inc. for testing and debugging. It is recommended that they not be used in production.

Name	Hex Value	Description
StatusGet	0	Return the status of the tester.
SequencePts	1	The pressure and/or time has changed
TestStart	2	A test has been started
TestResults	4	The test has ended.
Pressure	8	Pressure change but not doing a test
Program	10	The program and/or program parameter has changed
Configuration	20	Configuration parameter has changed
FlashConfig	40	Used for backwards compatibility.
Valve	80	Valve has opened/closed while not in test

Table 10 - Change-of-State Event mask bits

Channels Enabled

A bit mask indicating which channels or ports are enabled.

Name	Hex Value	Description
None	0	No channels are currently enabled
Channel1	1	Channel one is enabled
Channel2	2	Channel two is enabled
Channel3	4	Channel three is enabled
Channel4	8	Channel four is enabled

Table 11 - Channels Enabled

Channel/Port Status

A channel (or port) can be in different states, depending on the type of test currently being run. Because it is possible to have multiple channels that can be run in sequence or concurrently each channel has its own status. The following table lists all the possible channel status. Based on the physical configuration of the tester some status will never be reported. For example, a pressure decay test will never report Burst Pass status.

Name	Numeric Value	Description
Testing	0	The default value. Is testing or ready to test.
Pass	1	Test passed on this port
Abort	2	Test was aborted
Leak	3	Test failed because of a leak
Occl	4	Occlusion error
PerrH	5	High pressure error
PerrL	6	Low pressure error
Gross	7	Gross leak error

HFlow	8	High flow error
LFlow	9	Low flow error
NoBurstH	10	Burst at high pressure
NoBurstL	11	Burst at low pressure
NoBurst	12	Burst didn't occur
HCrack	13	High pressure crack
LCrack	14	Low pressure crack
NoCrack	15	Cracking didn't occur
Increase	16	Pressure is higher than the max allowed
ReferenceLeak	17	The differential side of the sensor has a leak
MaxDiffReached	18	Max pressure difference between the two ports allowed before the break
HReseat	19	Pressure was too high on a reseat test
LReseat	20	Pressure was too low on a reseat test
Fail	21	Unknown failure.
AutoCalSelect	22	Internal value used by Z-axis Inc.
Disabled	23	Channel/port is disabled
HBackPres	24	High back pressure
LBackPres	25	Low back pressure
ZeroError	26	Zero pressure is elevated
ClampPres	27	Clamp pressure error

Table 12 - Channel/Port Status

It is recommended that the Boolean Pass/Fail flags be used to determine if a test passed and/or failed and the port status only be used to indicate why the failure.

Because of timing not all sequences will be seen by the PLC. For example, if the Venting sequence is set to auto, it is possible that parting being tested could be vented before the next RPI and thus not seen by the PLC.

Config Flags

Boolean flags used in the configuration class.

Name	Hex Value	Description
None	0	No flag set
MirrorDataLogging	1	Output data logging on port 23 as well as 8023
Concurrent	2	Run test concurrently on all channels
VacVent	4	Enables ability to turn on vacuum vent on settings page
VacFlow	8	Vacuum e.g. negative flow, False = Positive flow
ZeroThreshold	10	Checks that the zero pressrure isn't elevated between tests
ElecRegAlwaysOn	20	Electronic regulator is always on, else false
LinkedFail	40	Linked programs that fail cause tests to fail
BuzzerDisabled	80	Buzzer is disabled
DisableEthernetIp	100	Disable EtherNet IP communication from a PLC
UsbEnabled	200	Enable the use of the Thumb drive
GlobalPassLink	400	Only sends the global pass on linked programs at the end of the linked programs
MultiDac	800	Enables using multiple DACs for one test

Minutes	1_000	Enables minutes timers to show on screen
RetestDisabled	2_000	Retesting is disabled
HibernationEn	4_000	Enables ability to hibernate after 30 minutes
AckFailEn	8_000	Pop up on the screen to show failure, user must acknowledge
ConcAsSeq	10_000	Concurrent tester that only allows one channel at a time
MultiSensorSeq	20_000	Sequential tester that has a sensor per channel
LoudBuzzer	40_000	Enables a loud buzzer valve callout
Custom	80_000	Flag for enabling custom features
CustomFlowUnits	100_000	Use custom flow units straight from sensor
DontShiftSensor	200_000	Concurrent but looking at same sensor
PrefillStartPress	400_000	Allow a starting pressure for prefill
LinkedTestAcknowledge	800_000	Add mandatory acknowledge page for linked tests
LinkedTestsSummary	1_000_000	Add a summary to the end of a string of linked tests
DisableSwipeFeature	2_000_000	Disable the swipe feature
DisableASCIIEcho	4_000_000	Disable the ASCII echo on LAN port 23
ManualTrigger	8_000_000	Footswitch manually triggers the burst
Cycles	10_000_000	Enables cycles for pressure decay tests
ZSpanEnable	20_000_000	Enables ability to turn on ZSpan on settings page
CFR	40_000_000	Turns on 21 CFR part 11 features such as user login and audit trail

Table 13 - Configuration Flags

Data Logging Flags

The data logging bit mask determines which events are written to the log files.

Name	Hex Value	Description
Off	0	No data logging is done.
ResultsOnly	1	Only test results are logged.
Detailed	2	Information is logged for each test step and test results.

Table 14 - Data Logging Flags

Flow Units

Units used to display flow values.

Name	Value	Description
sccm	1	Standard Cubic Centimeters per Minute
slm	2	Standard liter per minute

Table 15 - Flow Units

Pressure Units

An enumerator indicating the units that pressure values will be displayed in.

Name	Value	Description
Psig	1	Pounds per Square Inch Gauge
Mbar	2	Millibar
MmHg	3	Millimeters of mercury
InH2O	4	Inches of water
KPa	5	Kilopascal
CmH2O	6	Centimeters of water
InHg	7	Inches of mercury

Table 16 - Pressure Units

Status Flags

Bit or Boolean flags found in FlagStatus tag.

Name	Hex Value	Description
None	0	No flags set used internally.
Busy	1	Tester is currently busy running a test.
GlobalPass	2	All channels passed the last test.
GlobalFail	4	All channels failed the last test.
Fail_1	8	Channel one failed the last test.
Fail_2	10	Channel two failed the last test.
Fail_3	20	Channel three failed the last test.
Fail_4	40	Channel four failed the last test.
Pass_1	80	Channel one passed the test.
Pass_2	100	Channel two passed the test.
Pass_3	200	Channel three passed the test.
Pass_4	400	Channel four passed the test.
AntiTie	800	Anti-Tie bits are enabled
Interlock	10000	Interlock bits are required
Abort	20000	Test was aborted
ZSpanError	80000	Z Span error. Currently not used.

Table 17 - Status Flags

Program Flags

The following table describes the available Boolean flags that can be OR 'ed together and change the behavior of a given program.

Name	Hex Value	Description
None	00	No flags set
ElectronicRegulator	01	Use the electronic regulator when running the program.
ClampHoldFail	02	Hold clamps on when test fails
LeakStd	04	Use leak standard when running the test.
VentTimed	08	The vent step is timed, else vent till zero pressure.
EnableIncreaseLimit	10	Allow pressure to increase at start of test.
EvaluateAtEndOfTest	20	Wait till the end of the test to evaluate pass/fail.
StatsEnabled	40	Enable statistics for this program.
CSVent	80	Close vent valve during test
ZSpanEnabled	10_000	ZSpan is enabled for the program

Table 18 - Program Flags

Test Step

Based on the selected program settings a test consists of several steps or sequences. Some sequences are not needed if a given setting is zero or not selected. For example, if the pre-fill time is set to zero, no pre-fill sequence will be performed. The following table lists all possible sequences.

Name	Value	Description

Idle	0	The Tester is currently idle.
Clamp1	1	Clamp 1 step is being performed
Clamp2	2	Clamp 2 step is being performed
Clamp3	3	Clamp 3 step is being performed
Clamp4	4	Clamp 4 step is being performed
PreFill	5	Pre-fill step
Fill	6	Fill step
Settle	7	Settle step
Test	8	Running a test
Vent	9	Venting
UnClamp4	10	UnClamp 4 step is being performed
UnClamp3	11	UnClamp 3 step is being performed
UnClamp2	12	UnClamp 2 step is being performed
UnClamp1	13	UnClamp 1 step is being performed

Table 19 - Test Steps

Because of timing not all sequences will be seen by the PLC. For example, if the Venting sequence is set to auto, it is possible that part being tested could be vented before the next RPI and thus not seen by the PLC.

Available Test Types

Leak testers can be configured to perform several different types of tests. No Leak tester supports all test types and typically only has two or three valid types depending on the physical configuration. The following table lists all possible types for completeness only. Available test types is a bit mask that can have more than one bit set.

Name	Value	Description
Pd	0x0001	Pressure Decay
Pocc	0x0002	Occlusion
Vd	0x0004	Vacuum Decay
Vocc	0x0008	Vacuum Occlusion
Flow	0x0010	Flow
Burst	0x0020	Burst
VBurst	0x0040	Vacuum Burst
Crack	0x0080	Crack
Pd2	0x0100	Pressure Decay 2
Flow2	0x0200	Flow 2
ChambPres	0x0400	Chamber Pressure
ChambVac	0x0800	Chamber Vacuum
BPFlow	0x1000	Burst Pres Flow
Volume	0x2000	Volumetric
Reseat	0x4000	Valve Reseat
Burst2Stg	0x8000	Burst two stages
Differential	0x10000	Differential PD
BurstWeep	0x20000	Slow Open Burst

PxerVxer	0x40000	Pressure Exerciser
FlowCrack	0x80000	Flow spike
BackPressure	0x100000	Back Pressure
Retrograde	0x200000	Testing only

Table 20 - Test Types

Test Types

The current test type value reported back to the PLC is a numeric value. No Leak tester supports all test types and typically only has two or three valid types depending on the physical configuration. The following table lists all possible types for completeness only.

Name	Value	Description
Pd	0	Pressure Decay
POccl	1	Occlusion
VacD	2	Vacuum Decay
Voccl	3	Vacuum Occlusion
Flow	4	Flow
Burst	5	Burst
VBurst	6	Vacuum Burst
Crack	7	Crack
PD2	8	Pressure Decay 2
Flow2	9	Flow 2
Chamb	10	Chamber Pressure
VChamb	11	Chamber Vacuum
BPFlow	12	Burst Pres Flow
Volume	13	Volumetric
Reseat	14	Valve Reseat
Burst2Stg	15	Burst two stages
Differential	16	Differential PD
BurstWeep	17	Slow Open Burst
PxerVxer	18	Pressure Exerciser
FlowCrack	19	Crack with Flow
BackPressure	20	
Retrograde	21	

Table 21 - Test Types

Fill Mode

Value indicating the type of fill mode.

Name	Value	Description
Timed	1	Fill for a given time
Ramp	2	Fill ramping up to a given pressure
Auto	3	Fill automatically as fast as possible
AutoRamp	4	Fill automatically ramping up

Table 22 - Fill Mode

Valve Mask

Bit value indicating which valves are opened/closed. The standard valve mask is shown below.

Valve Name	Hex Value	Valve Name	Hex Value
Leak Standard	0x10	Vacuum	0x04
Clamp 1	0x80	Clamp 2	0x40
PD Pre-Fill	0x03	VD Pre-Fill	0x11
PD Fill	0x03	VD Fill	0x11
PD Settle	0x02	VD Settle	0x00
PD Test	0x00	VD Test	0x00
Occ Pre-Fill	0x03	VOcc Pre-Fill	0x01
Occ Fill	0x03	VOcc Fill	0x01
Occ Settle	0x02	VOcc Settle	0x00
Occ Test	0x08	VOcc Test	0x08
Flow Pre-Fill	0x18		
Flow Fill	0x18		
Flow Test	0x18		

Table 23 - Valve Mask bits