**Best Practices for**

**Remote Control Applications**

OVERVIEW:

The Mission managed SCADA system can be used to automatically or manually control a device at one location, based on a condition at another location. Automated remote control functions are described as Tank and Well Control, Digital Intertie and Analog Intertie.

Tank and Well control relies on the value of an analog transducer (level or pressure) at the tank to open or close relay(s) at remote terminal units (RTUs) typically located at well sites. Digital Intertie is used when the value of a digital input on the source remote terminal unit (RTU) causes a relay to open or close at the controlled or destination RTU. Analog Intertie is where a 4-20 mA signal is mirrored from one RTU to another.

A well-designed and operated system can make a temporary failure nearly transparent and give a timely warning of an extended failure. We offer this Best Practices document to aid you in the design, installation and operation of systems that perform control functions on your remote assets. In this paper we discuss:

* System design for fault tolerance
* Alarms and alerts that function as an early warning system
* How to use the system to maximize equipment life
* How to use the system to minimize energy costs
* The importance of staff training
* The importance of testing

This document is not an installation or training manual. The “Tank and Well Control Package” document (lit code TW) is available for a high level understanding of that system. Likewise, Mission hardware includes an Installation Manual while the web portal includes a System User’s Guide on the Documents page. Third party sensors, control panels and accessories also include owner’s/operator’s manuals. Please read and understand those documents. Finally, Mission offers training webinars and technical support at no charge to all of your staff. You may sign up for the webinar [here](http://www.123mc.com/webinarsignup.asp) (www.123mc.com/webinarsignup.asp).

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ALARMS AND NOTIFICATIONS

Many of the items discussed in this document result in automated alarms or alerts to your staff if an off-normal condition exists. It is therefore vital that the system be populated with the names and contact methods of the various operators. These settings should be periodically tested and reviewed.

The Mission messaging system is based on alarm “destinations” and “schedules.” Streaming videos are available [here](http://123mc.com/trainingVideos.asp) ([www.123mc.com/trainingvideos.asp](http://www.123mc.com/trainingvideos.asp)) that explain the alarm callout set up options. You will increase the likelihood for quick problem resolution by assigning specific types of alarm events to notify specific staff members. Since we never know if or when a utility will be compromised during a natural disaster, a full variety of communication methods should be included with your alarm call outs. These include cell phone, land line phone, text message, email, fax and pager. A variety of your staff should be included in case the primary on-call members are unable to acknowledge the alarm notifications. Call-out cycles are available to allow time for alarms to be acknowledged by staff so that “the boss” is only called as a last resort.

By default, the Mission messaging system directs alarms based on four general types of alarms (alarm, communication, wire fault and pump starts). These groups can be further refined down to a single input. Call-out logic can even analyze compound conditions. For example, “alarm on low chlorine, but only when a pump is running.” Mission technical support is available to discuss the best approach to complex alarm conditions you may encounter.

Unimportant alarms not only waste operator time, but they obscure important alarm events. Nuisance alarm suppression features are available throughout the Mission system. Digital inputs can be set with debounce settings and alarm call outs can be delayed. For example, a three minute alarm call out delay may be appropriate for a float switch that bounces in and out of alarm before it settles on one state. Swinger mode is another alarm suppression feature which is described [here](http://www.123mc.com/newsletter08.asp#LETTER.BLOCK30).

Alarm call outs can be disabled for an entire unit or a specific input. They can also be disabled anywhere from 30 minutes to an indefinite amount of time. Mission discourages disabling an entire RTU for alarm call outs indefinitely. If a sensor is problematic, disable only that input and utilize the time setting so that it will be automatically be re-engaged after the anticipated repair period. The web portal includes a report of disabled inputs. Review this list periodically and properly resolve the root cause.

Further assistance with configuration of alarm call out settings is available from tech support, webinars, streaming videos and newsletter articles.

COMMUNICATION AND POWER TOLERANCE:

The source data (tank level, digital input status, etc.) is transmitted, analyzed and stored on Mission servers. Commands are dispatched to the destination RTUs. The system relies on the cellular data network for these communications. In other words, control functions are dependent on both the source and destination RTU being online and functioning.

The cellular radios utilized by Mission automatically connect to the “best” tower in the area. By following the antenna placement best practices guidelines in the installation manual you increase the chances the RTU has more than one tower within range with which it can communicate.

Cellular providers occasionally perform system maintenance on their towers in the early morning hours. These outages generally take less than 30 minutes. Natural disasters or other problems can cause longer outages. The system should be designed to accommodate short duration communication failures and notify the operator of extended outages. In all cases, the system should be designed to fail in the best mode possible. For example, if the system is completing a fill cycle and the tank RTU were to go off-line, is there enough space above the pump off setting to accommodate a typical communication failure duration?

* In the event of a communications failure at the controlled (well) site, the Mission system can be set to fail with relays in the current state or to return to the normal state. Generally, pump relays are wired normally open (NO) or to run when a relay is energized. Mission RTU relays can be paged to one of two conditions on communication failure:
* no relay state change upon communication failure
* deenergize relay upon communication failure.
* Pumps Running (energized relay): This is appropriate if tanks can “spill.” Local control should insure that the well pumps do not operate if they are dry. Provisions should be made such that run-off is channeled to not damage the surrounding area.
* Pumps Not Running (deenergized relay): This is appropriate in a pressurized tank system, but requires human intervention to assure water is available when a communication link is not present. The overall system design must include adequately sized tanks to accommodate worst-case scenarios.
* Current State: This may be appropriate, if tank spills are not a problem and tank capacities are large enough to accommodate demand until the problem is resolved.

Communication failure at the tank results in the wells continuing in their current state based on the last tank reading. The operator can manually operate the pumps via the tank and well page within the web portal if the well RTUs are online or the pumps can be operated locally. In other words, the well pumps can be taken off of AUTO mode until the tank level reading is reporting properly. When manually operating well pumps via the web portal, it is helpful to look back at typical fill cycles. It is imperative to make sure the control design includes a local Hand Off Auto (HOA) on-site control switch or PLC that can handle preprogrammed conditions when required.

In the event of a communications loss, contact Mission Technical Support by phone or by submitting a ticket via your web portal to make changes to the relay position. It should be noted that a hardware failure of the Mission RTU effectively results in a communication failure, but would likely cause the output relays to default to their normal deenergized position.

In the event of an AC power failure, the Mission RTU will operate on battery and cause an AC failure alarm to be dispatched after five minutes. Active devices like analog transducers and relays powered from the Mission system will affect the available time the RTU can operate off of battery power. Digital sensors (floats) do not affect the available time. Battery capacity declines with age and temperature. Batteries larger than the standard 12V 5AH battery are available from Mission or local sources. We recommend batteries be tested annually and replaced every other year.

LOCAL CONSIDERATIONS

Perform as much local control as possible. Remote control should not be used for systems requiring frequent state changes and tight timing tolerances like lift station control. Remote control of wastewater applications are not permitted by Mission unless reviewed and approved by appropriate Mission personnel.

Include local control components in a redundant or fail-safe mode when possible. Examples include local mechanical pressure switches to stop well operation if local line pressure exceeds a desired value. A sensor can be included on the well pump control circuit to prevent a pump from running dry. A thermal sensor can be included on the volute of the pump to prevent seal or bearing damage due to over temp. Local alarm lights and buzzers can be included.

The required level sensor for tank and well applications is a precision electro-mechanical device that can fail as a result of freezing, lightning strike, water penetration or mechanical strike. They generally don’t fail of “old age.” A spare should be available in the case of a transducer failure. A warm spare can be quickly put into the active mode with a phone call to Mission technical support.

Surge suppression, lightning protection and good wiring practices can reduce the chances of a failure due to lightning. Carefully follow the installation guidelines supplied with analog devices. Shielded wire is recommended with the shield connected to the ground on one end (Mission RTU). Surge suppressors are generally installed as close to the instrument as practical. Control cables should not run parallel to AC wires due to induced voltage that will cause spikes. Instead, they should run in a separate conduit. If AC and control cables must cross, do so in a perpendicular fashion.

Alarm set points should be entered with all analog sensors. For reasons described above, a secondary method of level detection can be considered. Alarm set points can be set to that sensor in addition to the primary. Alternately, high and low floats can be included for secondary alarming purposes.

Consider all weather extremes when designing your system. The pipe stub serving in-line pressure transducers can be one of the first items to freeze since there is little flow in a stub. This will render the instrument temporarily or permanently inoperable. Installation below the frost line, heat tape or grease-filled isolation glands are ways to minimize freezing. Optimumoil.ca is one supplier of isolation glands.

Submersible transducers located in above ground tanks can freeze in place. Consider a mixer or bubbler to keep the water moving so the hanging cable won’t be constrained by a sheet of ice. Enclose the cable in PVC pipe to prevent ice from trapping the cable.

Flood conditions can swamp a service pit and damage components. Some transducers are built to survive flooded conditions. You must also consider the wire terminations.

Solar powered RTUs lose capacity during the winter months and inclement weather. Size solar panels and batteries for the extreme situations and periodically clean and adjust the panel, trim shade trees and replace old batteries.

You may consider additional analog sensors for flow and chlorine levels. The analog option board expands the RTU from two analog inputs to six. The M800 model RTU is recommended for most applications requiring transducers and all applications that are used for remote control of any kind.

INFRASTRUCTURE

Every system is unique from a hydraulic and mechanical standpoint.

* Tanks that are plumbed in parallel, but have valves can impact the placement of sensors. Include what-if scenarios in your training to anticipate various valve settings.
* Larger tanks that stay nearly full supply more water if a communication failure were to occur. They offer less leeway before a spill if they are over-filled.
* Tanks that utilize the off-peak energy saving feature are not always as full. This means less reaction time.

POSITIVE RELAY FEEDBACK (PRF)

There are several reasons a pump or other device may not run when commanded to do so:

* Circuit breaker or Hand-Off-Auto (HOA) switch is OFF
* Phase loss
* Thermals or overload blown or tripped
* Device is defective
* Control circuit to device is defective
* Controlled RTU is offline

The Positive-Relay Feedback alarm is a set of business logic that tests six different conditions and alarms if something is not operating as expected. These conditions include:

* Pump failed to run – relay is closed, but pump did not start before feedback-delay timeout
* Pump failed to stop – relay is open, but pump did not stop before feedback-delay timeout
* Pump started prematurely – relay is open and pump is stopped. For some reason pump started to run when relay is still open
* Pump stopped prematurely – relay is closed and pump is running. For some reason pump is stopped when relay is still closed
* Pump stopped and is now operating normally – relay is open. For some reason pump is still running. As soon as pump is stopped when relay is still open, operators will receive the alarm.
* Pump started and is now operating normally - relay is closed. For some reason pump is not running.  As soon as pump starts running when relay is still closed, operators on the alarm callout list will receive this alarm.

PRF requires a digital input be wired so the state of the controlled device (well pump for example) is known. This can be accomplished with any dry contacts that operate consistently with the pump or the optional Mission Wet Well Module. The Wet Well Module uses strap-on current sensors to determine pump run status when the pumps draw more than ~5 amps. It is therefore a more accurate indicator that a pump is running than the control circuit on the same pump when the sensor is located below thermals or overload.

With the PRF alarm set, a notification will be dispatched if the pump or device did not operate as expected. The root cause of the failure can include:

* + Pump locally set to Off or On at HOA switch off
	+ Breaker tripped or burned out pump
	+ Local wiring problem that causes pump to never start
	+ Local lock out engaged (over-temp, low well level, etc.)
	+ Pump under control of two competing control methods.

Diagnostics related to PRF will be easier if sensors related to these conditions are actively monitored by the Mission RTU. For example, an additional set of switch contacts can be added to many HOA switches. Add an additional switch to the ON side of an HOA switch (effectively making that position a double pole switch. Wire those poles to a Mission Digital input. Whenever the HOA switch is not set to Auto the corresponding DI will be in the off normal or alarm position. By setting an alarm delay on that input via the web portal, operators can test the pumps (hand switch position). If the operator fails to return the switch to the Auto position in a reasonable period of time, an alarm will be called out. For the convenience of operators, the off-normal label for that input can be described as “HOA Switch not in Auto” via the web portal.

TANK AND WELL

From the Tank and Well area of the web portal, pumps can be put in Automatic, ON or OFF modes. Lead and lag set points can be changed. Lead, Lag 1, Lag 2, Lag 3 and Lag 4 pump roles can be assigned and changed.

The pump icons actually indicate the status of the Mission relays. Use the Positive Relay Feedback Alarm to notify your staff of a mismatch of relay state versus pump run status.

The alternator can be switched on or off. Please note that the alternator will alternate all configured pumps.

You can select a maximum runtime for each pump, which allows equal runtime distribution across all pumps. Once the first pump reaches the maximum runtime, the system will alternate to the next pump. This feature allows pumps to rest and gives groundwater sources time to recover.

MAXIMIZE EQUIPMENT LIFE & ENERGY SAVINGS

Nightly force fill is an energy cost saving feature that is useful if your electricity rates have a time of day cost differential. Contact Mission Tech Support for information on the setup of this feature.

Pump start notifications can be set to alert or alarm (email or phone, respectively) on a user selectable number of starts per hour. Similarly, an alert can be dispatched based on a variance of normal pump runtimes. By properly understanding and acting on these occurrences, you may be able to extend your equipment life or perform preventive maintenance at a convenient time.

ANALOG INTERTIE

The analog output option board sources a 4-20 mA signal as a result of a page to the RTU (Commands menu) or automatically by way of mirroring a source RTU analog input. Setup for this must be done by a Mission technician.

Positive feedback of an analog output can be achieved by wiring a Mission Analog input into the same loop as the output. The output can then be verified via the web portal under Data/Analog Data or on the map pop-up.

Considerations should be made for the controlled device operation when the Mission RTU is off-line.

USERS AND SECURITY

Unique user credentials (user name and password) should be assigned to each operator. Mission has the ability to setup a SuperAdmin user to control specific privileges and credentials. Tech support can attach an administrator's email address to the system so that every time a change is made to an operational setting a "before/after" email is sent to the administrator. The administrator should verify and test that the change yields the expected result.

For security reasons some system settings must be set by Mission Tech support staff. They can be reached by dialing 877-993-1911, option 2.

TESTING AND TROUBLESHOOTING

Various failure modes should be tested periodically in a controlled manner. For example, while on site completely fill the tank so that the exact spill level is known.

* Confirm that high-analog alarm thresholds are appropriately lower than the spill height. If the output of transducer or transmitters do not agree with the signal Mission is receiving, calibration of equipment may be required.
* Cause Positive Relay Feedback conditions to occur and confirm alarm call outs are as expected.
* Fail the power and communications to confirm fail-safe conditions.

Reports are available on your web portal which include time stamps of the various data inputs and commands to RTUs. By carefully looking at the time stamps of digital data, analog data and the operations log, you can determine the cause/effect relationship of the variables.

KNOWN LIMITATIONS

Automated remote control functions rely on a combination of real-time programs that evaluate data (typically every two minutes for M800 analog values) and check- up programs that periodically verify conditions are as they should be, based on the database information. Give the system some time before jumping to conclusions or making additional changes when configuration changes are made. Most of the time, three minutes is appropriate for the changes to settle (a 5% or higher change will cause the analog data to be immediately sent).

The Mission system allows an admin user to directly page a device for current readings or to control a relay. The automated remote control systems cycle through the various settings and within a minute or so will over-ride any manual pages to a relay. Because of this, any Off, On or Auto settings should be made at the Tank and Well or Interconnect control page.

Changes to the alarm set points and scaling for analog 1 and 2 will be recalculated and paged to the RTU. This does not apply to changing Tank and Well set points.

TRAINING AND DOCUMENTATION

System documentation should be consistent and unambiguous. Label all devices clearly for all operators. PumpStation 1 is less descriptive than River Road Pump Station. An input in the Mission system labeled as Pump #1 should be described that way on drawings as well as in the pump house. If possible control Pump #1 by Relay #1 to avoid confusion.

Operators and recipients of the notifications must understand how the system works and the tools at their disposal. All stakeholders are encouraged to attend and ask questions at the free weekly Mission webinars. Sign up at www.123mc.com.

A training plan should be established so all stake holders understand the system operation and limitations. The following checklist can be used as a starting point of your training program.

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| **ITEM** | **DESCRIPTION** | **DESIGN/BUILD** | **TRAIN OPERATORS** | **TEST/ INSPECT FREQUENCY** (annually unless described otherwise) |
| Failure mode | Define how system should operate if communications is lost. |   |   |   |
| Local control | Consideration of "fail-safe" precautions (local control) if primary system does not respond as expected. |   |   |   |
| Secondary sensors  | High/low level floats installed and appropriate for worst-case alarm purposes. |   |   |   |
| Documentation | Design schematic, “as-built” drawings and appropriate diagrams/ manuals located at each location and the main office. |   |   |   |
| Training | Staff trained on overall system, web user interface and maintenance procedures. Train new staff. |   |   |   |
| Installation  | Verify professional workmanship and test operation. |   |   |   |
| Service | Critical spare parts available, technicians trained. |   |   |   |
| Pump set points (analog "run" settings) | Check tank level, lead/lag for all pumps and alternator settings. |   |   |   |
| Alarm set points (analog alarm settings) | Alarm thresholds are entered for the tank level analog channel. Should the wells not run for an unknown reason or there is a large leak, the tank may drain more quickly than the wells can fill it. Appropriate alarm set points can notify your personnel of this condition. |   |   |   |
| Digital | Proper input type (runtime, alarm, status) set and inputs labeled. |   |   |   |
| Communication alert time | Be sure that the alarm thresholds are entered for the tank level analog channel.Should the wells fail to run for an unknown reason or there is a large leak, the tank may drain more quickly than the wells can fill it. Test these thresholds a minimum of once a year. |   |   |   |
| Call out list | Operators’ names, schedules and contact methods must be up-to-date with enough detail in lists to accommodate vacations etc. |   |   |   |
| Operator Credentials | Unique login credentials should be set for each operator, individual "service" keys issued and login privileges set. System "expert" is defined as administrator or Superadministrator. |   |   |   |
| Web User Interface | Operators will be trained on UI. RTU installation setup form must be completed and sent to Mission, so that all items are clearly described on web page (text-to-speech, input names, location, etc.). |   |   |   |
| Full system tests | Inspect, calibrate and test system end-to-end by manually tripping appropriate inputs and verifying that messages are delivered according to your call out schedule and results are as expected. Check the backup battery. |   |   |   |