CONSIDERATIONS FOR CHOOSING A REMOTE MONITORING SYSTEM FOR CATHODIC PROTECTION RECTIFIERS

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ABSTRACT
When choosing a remote monitoring system for your cathodic protection rectifiers there are many things to consider such as: do you want the ability to poll and control your rectifiers’ output or are you looking for an inexpensive system to satisfy code requirements [1]? Do you have an existing radio network or will you have to rely on an outside service provider? These are only some of the many questions that require answers before a decision can be made as to which of the many remote monitoring systems available is best suited for your cathodic protection monitoring program.

This paper examines many of the questions that need to be answered prior to choosing a remote monitoring system and also discusses the pros and cons of the many options available to the industry.

This will allow the reader to make informed decisions when choosing a remote monitoring system and hopefully avoid the costly mistake of installing a system that does not meet your requirements now and in the future.

1 - INTRODUCTION
A cathodic protection system must operate continuously to be effective. This requires that either the power source(s) for the cathodic protection (CP) system or reference potentials be monitored at routine intervals so that problems can be detected early. A more frequent monitoring interval will help to reduce the cathodic protection outages and thus assist in preserving the asset. The longer the periods of undetected problems, the longer the accumulated time that the CP system may be inoperative in turn allowing the structure to corrode. This lost metal cannot be replaced.

Regulations pertaining to structures protected by cathodic protection (in Canada CSA Z662 [1] and the accompanying OCC-1 [2]) and good operating practices (NACE RP 0169) contained in many company in-house operating procedures require the “verification of proper rectifier operation” on a monthly basis. Manual monitoring can mean devoting many man-hours each month traveling along a long pipeline route checking each rectifier, or simply walking across the compressor station yard. Depending on your requirements, remote monitoring may or may not be suitable in either of these situations.

With the advancement of communication technology virtually any rectifier can be monitored remotely. The equipment required for remote monitoring consists of, a remote monitoring unit (RMU) installed at the rectifier, a base computer with the appropriate software, and a communications link between the RMU and base computer. The cost of RMU’s installed can range from approximately a few hundred dollars to many thousands of dollars per unit and operating costs per unit can range from $0 to more than $60/ month. With the number of options available it is therefore important to get both the most cost effective and the most suitable RMU for your cathodic protection system.

2 - DISCUSSION
Depending upon the type of remote monitoring unit (RMU) installed, the advantages of installing a remote monitoring system could be:

- Accurate, up to the minute information;
- Remote rectifier troubleshooting capability;
- Immediate notification of rectifier outages;
- Remote synchronized interruption of rectifiers;
- Archived data records;
• Increased productivity of dedicated corrosion personnel.

Some of the disadvantages (cons) of a remote monitoring system may include:
• Less preventative maintenance on the rectifiers;
• Out of sight, out of mind with regards to cathodic protection;
• Loss of secondary observations i.e. ROW activity;
• Initial cost can be quite high.

Prior to the purchase and installation of a remotely monitored system for your cathodic protection rectifiers the pros and cons of remote monitoring verses monthly site visits by trained personnel must be carefully reviewed. Is the main objective to optimize your cathodic protection system by having accurate, up to date readings or is it to save operating dollars on monitoring?

Once the decision is made to install a remote monitoring system, the next step is to decide which RMU to purchase.

There are four distinct components to a remote monitoring system.

1. The rectifier is the first component of the remote monitoring system. Obviously, without the rectifier there would be no reason for a remote monitoring system. Consider the merits of replacing old and/or undersized rectifiers in conjunction with a remote monitoring system program. Some RMU suppliers have partnerships with rectifier manufacturers and can supply a RMU, preinstalled in rectifier ready for installation. (Figure 1).

2. The next component is the RMU at the rectifier. This unit gathers the rectifier information and prepares it for transmission. Depending upon the manufacturer and the model the RMU may also incorporate a remotely operated current interrupter into the circuit for use in “instant off” cathodic protection surveys. (Figure 2)

Figure 1: FACTORY INSTALLED RMU READY FOR SHIPPING

Figure 2: An Example Of An Internally Mounted Rmu With Satellite Communication

3. The communication system transmits the data gathered by the RMU. This communication system may be owned and operated by the user or may be provided by an independent service provider such as a cellular phone company.

4. The final component of the remote monitoring system is the base station that consists of a communication interface and a base computer. (Figure 3) Here the data sent from the RMU is received, stored and any commands to the RMU are transmitted.
Without any one of these components, remote monitoring of the cathodic protection system would not be possible.

Requirements – Remote monitoring unit

The first step in developing a remote monitoring program is to identify your requirements. Prepare a list of all your requirements for comparison to the RMU manufacturers’ specifications. If there are requirements that do not appear on the manufacturers’ specification sheet do not hesitate to contact the manufacturer and ask if the requirement can be met and, if yes, at what additional cost. This first step should include identifying the following:

- What is to be monitored?
  At the very least, you will want to monitor the rectifier current. The more information collected by the RMU will not only provide more detailed records, it will also aid in remote rectifier troubleshooting if an outage were to occur.

The following is a list of data that can be remotely monitored:
- Total DC current;
- DC current of secondary circuits;
- DC voltage;
- Primary AC input voltage;
- Secondary AC input voltage;
- Structure-to-electrolyte potential;
- Anode string currents (if applicable);
- Back-up battery voltage;
- Rectifier tamper alarm;
- Non C P related information (pressure, temperature, flow).

Each item to be monitored requires an input channel therefore the number of available channels will limit the number of functions that can be monitored. All of the rectifier functions are analog inputs, however some functions such as tamper alarms, and the non C P related devices might require digital inputs. Confirm the type and number of inputs the RMU will require and compare that to what is commercially available.

- Rectifier Polling:
  Some RMU’s, referred to as “dumb” units, (Figure 4) are single channel, one-way communication devices. They can only call out to a predetermined number on a set schedule. These units usually utilize a customer’s phone line and are unable to answer incoming calls; therefore no remote polling of the RMU is available. To avoid long distance charges appearing on the customer’s phone bill, the RMU must contact the host computer using a local or a toll-free number. The cost of setting up a toll-free line for this type of system has to be factored into the cost equation. As “dumb” units cannot be polled, remote interruption is not an option.

- Remote rectifier interruption.
  Remote rectifier interruption is an effective time and cost saving addition as it reduces field time during annuals surveys, especially if your system has many rectifiers with a great area of influence. For the interrupter to be effective, the interrupter must be...
GPS synchronized. The more often (once per minute) the RMU interrupted synchronizes itself the more accurate your survey results will be.

Note that some units will stop interrupting when the satellite signal is lost and fail in the “ON” position. When the signal returns they will again start to interrupt without notification that it was off. As all current sources must be interrupted to obtain a true polarized potential, inaccurate data will be result during this period of time. It would be preferred to have the unit continue to interrupt even though the cycle may be slightly out of synchronization. Stationary dataloggers should be used to confirm that a continuous interruption cycle has been maintained.

Some RMU interrupters are designed to start in the ON cycle while others start in the OFF cycle. If portable interrupters are to be used in conjunction with the RMU interrupters, both interrupters must start in either the ON or “OFF” cycle. Use an accurate clock such as that in a hand held GPS receiver to verify the cycle length and confirm which cycle starts at the top on the minute.

Some portable interrupters have a built-in time delay; therefore an adjustable interruption offset of the RMU interrupter is necessary. Again, this offset can be checked with a hand held GPS receiver to determine the offset of the portable interrupter.

For efficient close interval surveys, (CIS) a short interruption cycle of less than 0.5 seconds is necessary. A RMU interrupter with an on/off interruption cycle of one tenth of a second is recommended. On the other hand if an annual survey is being conducted, both a longer ON and OFF cycle may be desirable to enable the corrosion technician to record the observed potentials. An RMU that allows for quite a range of timing cycles is a feature that needs to be considered.

When multiple rectifier current interruption is required in order to gather true “instant off” potentials GPS synchronization of interruption cycles becomes important, as is the ability to select various interrupter time cycles. In those cases where the survey duration may be days or even weeks, the ability to suspend the interruption cycle during non-survey periods of a 24-hour day (to minimise depolarisation with elapsed time) is also a desirable option to consider.

The ability for the RMU receiver to receive and store a complete interruption schedule from the base computer with just one command is particularly beneficial when there are charges associated with communicating to the RMU such as cellular or satellite airtime fees.

The relay used to interrupt the rectifier can either be a mechanical or solid-state relay. The solid-state relays are more expensive, but there are no contact points to burn out, therefore they can be more cost effective over time. A RMU that utilizes a “normally closed” relay is preferred so a power failure to the RMU (but not affecting the rectifier) will not disrupt the rectifier output.

There may be the occasional need to interrupt the rectifier locally, not remotely. The RMU interrupter should be able to be activated either by a keypad on the RMU or by connecting a laptop computer to the RMU.

- Notification of rectifier outages;
- Battery back-up;
- Heaters;
- Surge Protection;
- RMU Power Supply;
- System upgrades.

The ability to upgrade the RMU is a very important consideration and one that may sway decisions in favour of one system over another. Additional questions to be considered in regards to being upgradeable are:

- Can the remote monitoring system handle the addition of a new rectifier?
Can firmware updates be loaded into the RMU and if so, can it be done remotely?

Requirements - Communication

Probably the most complicated component in the remote monitoring system is the communication link.

The first step in choosing a communication system is to determine which communication mode is available at each location. This information may not be readily available therefore a visit to each rectifier site may be necessary and in some instances a communication consultants may have to be brought in to determine what options are available.

Any communication system must have a strong clean signal to handle the data transfer rates or format listed below.

- **Two-way Radio (VHF/UHF) System:** Conventional voice grade Radio System - 1200 bps data rate;
- **PSTN (Public Switched Telephone Network):** Analogue grade - 1200 bps data rate;
- **Cellular:** Circuit Switched APS Cellular - 1200 bps data rate;
- **Satellite:** Data Service, 8/32 byte message format, email based;
- **Scada RTU:** Spare Channel Required, Modbus Interface.

Although simpler is often better, some manufacturers’ can handle multiple communication systems easily.

Typical communication systems available at rectifier sites may be:

- **Wired telephone;**
  This requires a telephone line running near the rectifier location. While this may be probable in an urban area, it is unlikely in remote areas. The cost of running a phone line in a remote area may be too prohibitive.

  Unless the RMU is a “dumb” unit, that is only able to transmit, not receive data, you will need a dedicated line for the RMU. This means a monthly phone bill for each rectifier using a hard-wired phone line. If you have a “dumb” RMU and an existing phone line is available, you should be able to piggyback onto the existing phone line and no additional operating cost will be incurred, except perhaps the cost of a 1-800 number.

- **Wireless phone;**
  Wireless phones, whether they are cellular or satellite are good alternatives when a wire phone connection is not available however they also have there limitations.

  - **Cellular phone**

  Cellular phone use is limited to locations within the cellular coverage area. While cellular coverage along a pipeline between Calgary and Edmonton may be assured, cellular coverage is virtually non-existent through the mountains of BC.

  Some RMU’s utilize data only cellular channels, while some require regular voice channels. Regardless monthly operating costs for each cellular phone unit will be incurred. These costs will vary between cellular companies and cellular plans within the same cellular company. Per call charges may apply or may be included, depending on the cellular phone calling plan arranged with the cellular provider.

- **Satellite phone**

  Almost every point in North America can be accessed by satellite phone unless shielded by local large obstacles, therefore this communication method is available to almost any rectifier in North America.

  A remote monitoring system utilizing this type of communication is a little more complicated as the data being transmitted and received by the remote monitoring system must be routed through the satellite service provider’s gateway. Typically, data is transmitted from the RMU, via a satellite, to the satellite service provider’s gateway. The data is then directed to the Internet through dedicated Internet servers at the satellite service provider’s gateway. From there the information is accessible via the remote monitoring system Base computer’s Internet connection. The reverse path is used when contacting the RMU from the host computer.

  There are many “satellite providers” however some satellite networks have fewer satellites, which means communications sent from the RMU may sometimes be delayed as the RMU waits for the satellite(s) to be in range. This can sometimes prevent immediate response from requests to the RMU.

  Operating costs for a satellite system can be expected to be higher than those associated with a cellular system. Hardware can be expected to cost $2000 to $4000, and airtime charges of $1.00/minute are not unusual.

- **Two way Radio.**

  Setting up a two way radio system exclusively for a remote monitoring system is cost prohibitive, however if a radio network exists, it is a cost effective method of communication for a remote monitoring system.
With a two-way voice radio system, the initial cost may be slightly higher than a cellular phone, but since there are no monthly operating costs and no connection fees this could be the cost effective solution to companies already equipped with radio a system. There is an annual licensing fee for the radio that has to be factored into the cost analysis.

Utilizing an existing voice radio system for data transmission can be a minor annoyance to other users of the system due to the squelch bursts each time data is transmitted. Scheduling rectifier polls and other requests during off peak hours can minimize this annoyance. Although some companies have radio systems have radio channels dedicated to data only transmission, installing this infrastructure solely for a RMU system would be costly.

Requirements - Base computer
A standard desktop computer is used to access the RMU system. The size and speed of the computer is determined by the software and storage requirements. A connection to the Internet or company intranet may be required.

Some suppliers of satellite and cellular remote monitoring systems have every poll request routed through their computer and charge for these request. The satellite or cellular phone may be in the supplier’s name and they may mark-up the service charges. To access the users own data they must connect to the supplier’s computer, usually via the Internet. This can be a cumbersome and costly system especially when there are a large number of rectifiers and the data is accessed frequently. On the up side, if the remote monitoring system is accessed by various users within an organization or from off site locations, access to the system via the Internet may be beneficial. How the user accesses the remote monitoring system therefore is another consideration in the selection process.

Requirements - Host software
Host software allows the user to interface with the RMU as well as manage the data provided by the RMU. The software should be capable of providing an immediate visual response to queries as well as have the ability to archive the data.

Prior to choosing a remote monitoring system the user should determine from the manufacturer if the price includes a host software package and if so, is it a custom or generic software package? Ask to review the software’s features and capabilities. If the software is found lacking ask the manufacturer if they can modify the software to better suit your needs and also do they offer technical support for the software provided. If the software proves to be too cumbersome or takes special computer skills to use, perhaps another supplier should be considered.

The more features a software package has, the greater control the end user has over the remote monitoring system.

Typically the RMU vendor will supply basic host software to control and poll the RMU’s; however some end users require software to integrate with their company GIS or pipeline data-base system. This custom software would most likely be developed or commissioned by the end user.

Features to consider when reviewing or designing a remote monitoring system’s host software package include:

- The ability to view the data, whether it’s the latest data from all rectifiers or all the historical data
associated with one rectifier, provides greater data flexibility, which translates to more value to the user;

- The ability to poll either all rectifiers at once or one rectifier at a time. This provides the operator with more control over the system. This also saves time when requesting information;

- Being able to remotely interrupt a rectifier is probably, second to data retrieval, the most beneficial feature of a remote monitoring system. The ability to interrupt one or all of the rectifiers with one command, regardless of the communication system chosen is a benefit;

- The ability to confirm interruption is very important; not only to verify the RMU received the interruption command, but also to provide the assurances to the personnel performing the associated field work that the data is accurate without having to physically confirm each rectifier is interrupting;

- An automatic data retrieval schedule allows for automatic data retrieval and storage, even when personnel are away from the office. An added benefit when using a two-way radio communications system is to schedule the polling for non-working hours which will eliminate the annoyance of data squelch and prevents the transmission of data over the conversations of others;

- The ability to send an interruption schedule for an entire week with only one command is a feature that also has to be considered, for example: start interruption at 07:00 hrs; end interruption at 18:00 hrs; repeat for 5 days. This means that the user only has to access the remote monitoring system once during a weeklong survey, saving time and decreasing depolarization of the pipeline overnight. For systems utilizing a communications system that has a per call fee, this also saves money (Only one transmission is needed for the above schedule as opposed to ten transmissions if the same schedule was sent manually);

- The report by exception is a useful feature, however if no one is monitoring the host computer the exception will go unnoticed. A notification feature that will page, e-mail or send a pre-recorded message to user’s voice mail provides an even more positive notification of an outage;

- To provide maximum control, one feature that is very important is the ability to access the host computer from the field. This can be achieved either through the Internet, the company Intranet a dial-up program such as “PC Anywhere” or a mobile command unit capable of accessing the RMU directly. Without this access, the field staff will have to rely on qualified personnel in the office to send commands to the RMU’s and relay the results back to the user in the field;

- With technology continually advancing, the ability to upgrade the host software is beneficial, as new features are added. Ask your supplier if software updates are included with your purchase.

**Costs**

There are two types of costs to consider when choosing a remote monitoring system: Capital costs and Operating costs. Some remote monitoring systems will involve high Capital costs but very low operating costs; others will have low capital costs but high operating costs and of course others will price out in between. Depending on how a company is structured, one system may be more favoured than the other, which again could be a deciding factor on which system is purchased.

Not many remote monitoring systems can be justified on cost savings alone. Adding to the formula - protecting assets with quick response to cathodic protection failures, accurate data keeping, and more efficient allocation of human resources makes the installation of a remote monitoring system a benefit to any company.

Costs to consider are:

- **RMU’s** can range in cost from a few hundred dollars to many thousands of dollars per unit;

- Operating costs typically can range from $0.00 to $60.00 per month or more;

- Add to that the installation cost of perhaps $100.00 to $300.00 per unit depending on many factors including travel time between units;

- A dedicated base computer with communications equipment could run $3000.00 to $5000.00;

- A vehicle mounted control unit that allows communication with the RMU if the communications system is a two-way radio network presently costs about $3000.00;

- A new rectifier if required may cost $1500.00 to $2500.00 depending upon the size and options;

- Depending upon the communications system of your RMU’s the annual cost may include some of the following: cellular/satellite airtime charges, cellular/satellite monthly service fees, radio licensing fees, and the cost of a 1-800 number.

A suitable performance holdback with the supplier should be negotiated in the contract to be paid when the system is operating as promised. The supplier should be able to
provide field service to correct any system deficiencies that arise.

**Installation and Commissioning**

Once the decision on which RMU to purchase has been made ask the supplier to provide you with a few test units. This will allow the user to test the remote monitoring system prior to purchase, to ensure the system operates as expected and that no considerations were overlooked.

- **Installation;**
  Depending on the number of RMU features and options, and the distance between rectifiers, a two-man crew should be able to install two units per day. Allow one day to install the base computer, and an additional one week for testing a system with 10-15 RMU’s.

Have the RMUs and all the materials required for the installation on hand in advance of the installation start date to prevent any installation delay due to missing components. The RMU supplier should be able to provide a detailed list of all the additional components necessary to install the units.

Depending upon your system, the base computer should be installed and operating first. This will enable you to test the RMU at the rectifier site once the RMU has been installed to ensure it’s proper operation.

On rectifiers equipped with GPS interruption RMU’s, make sure the GPS antenna has a clear view of the sky.

- **Commissioning.**
  Note: Depending upon the features included with your remote monitoring system some of the following tests may not be possible.

Once each RMU is installed, calibrate each channel to the actual rectifier values. Test the communications link to the host computer and compare the transmitted rectifier value to the actual values. Initiate an interruption cycle. Using a hand held GPS receiver, check the interruption timing to ensure it synchronizes itself at the top of the minute. Make sure it turns On/Off at the top of the minute, whichever was specified. Record all the data including rectifier data on an information sheet for your records.

After all the RMU’s are installed poll each unit from the host computer. Compare these polled readings to those on your information sheet.

Initiate an interruption cycle using a cycle of 1 second “on”, 59 seconds “off”. Re-poll the RMU’s. They should all record no volts and no amps. End the interruption cycle and re-poll the units. They should all be reporting the same readings as they did prior to the interruption cycle.

Initiate another interruption cycle using a 4 second “on”, 1 second “off” cycle. Using a data logger capable of recording 7-10 readings per second, take a one-minute pipe-to-electrolyte potential log at a test station mid-way between rectifiers. Review the log to confirm all the RMU interrupters are synchronized. Examples of typical datalogs obtained with the rectifiers in-sync and then out of sync are shown on Figures 8,9 and 10 respectively.

Test the commands to the host computer from a remote site if your remote monitoring system has this capability.

Turn off a rectifier using the external AC disconnect switch and wait for the RMU to report an AC failure. Similarly, disconnect the negative cable to confirm the transmission of a DC current failure. As some RMU’s disable the report by exception feature during interruption, confirm the interrupters are not operating during these two tests.

**Obstacles**

Some of the obstacles the Author has encountered are highlighted below.

- Limit the number of VHF radio repeaters between the RMU and the host computer to 3-4;
- Induced AC voltages may cause the RMU to report false readings;
- Ensure the AC service to the rectifier and RMU has an adequate, even oversized ground, especially in lighting prone areas;
- Mount antenna’s as remote of the AC service as possible to maximize transmission strength.

**Safety**

- Use the appropriate personal protective equipment. Review the job requirements before proceeding with the work and consult both the requirements in the appropriate provincial Workplace Health and Safety regulations and within specific company safety manuals;
- As the installation of most RMU’s requires wiring the unit into an AC circuit, the installation should only be completed by qualified personnel;
- As most rectifiers are located in remote areas and the installation involves AC power, a two-man crew is recommended;
- Locking out and tagging out of the rectifier’s external AC disconnect switch (Figure 7) is mandatory before installing the RMU. If the rectifier does not have an external disconnect switch, contact a qualified electrical contractor to install one prior to proceeding with the RMU installation. Checking for the existence of an external disconnect switch should be done during the initial “communications testing” site visit;

- Only use a fibreglass ladder while installing the RMU’s antenna (if so equipped). Use a ratchet tie down strap to secure your ladder to the pole to prevent slipping;

- Use extreme caution while installing the antenna near overhead power lines. Maintain as much distance as possible from the rectifier AC service lines and be both aware of and adhere to the minimum separation required between the overhead power lines and the antenna.

3 - CONCLUSION
A remote monitoring system is an effective method to monitor a cathodic protection system.

The more time spent determining the user requirements of a remote monitoring system the better equipped the user will be when “shopping” for a system. There are many pros and cons (both monetary and feature related) to the RMU systems that are available and comparing the user requirements to those remote monitoring systems available will allow informed decisions to be made. Additionally the RMU market is continually evolving and informed “shoppers” will continue to encourage the manufacturers to build better and more versatile systems.

4 - ACKNOWLEDGMENTS
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5 - REFERENCES
1. Canadian Standards Association CSA Z662, Oil and Gas Pipeline Systems
2. Canadian Gas Association CGA OCC-1, For the Control of External Corrosion on Buried or Submerged Metallic Piping Systems
Figure 8: Log Of Synchronized Interrupters

Figure 9: Log Of Un-Synchronized Interrupters

Figure 10: Log Of Un-Synchronized Interrupted