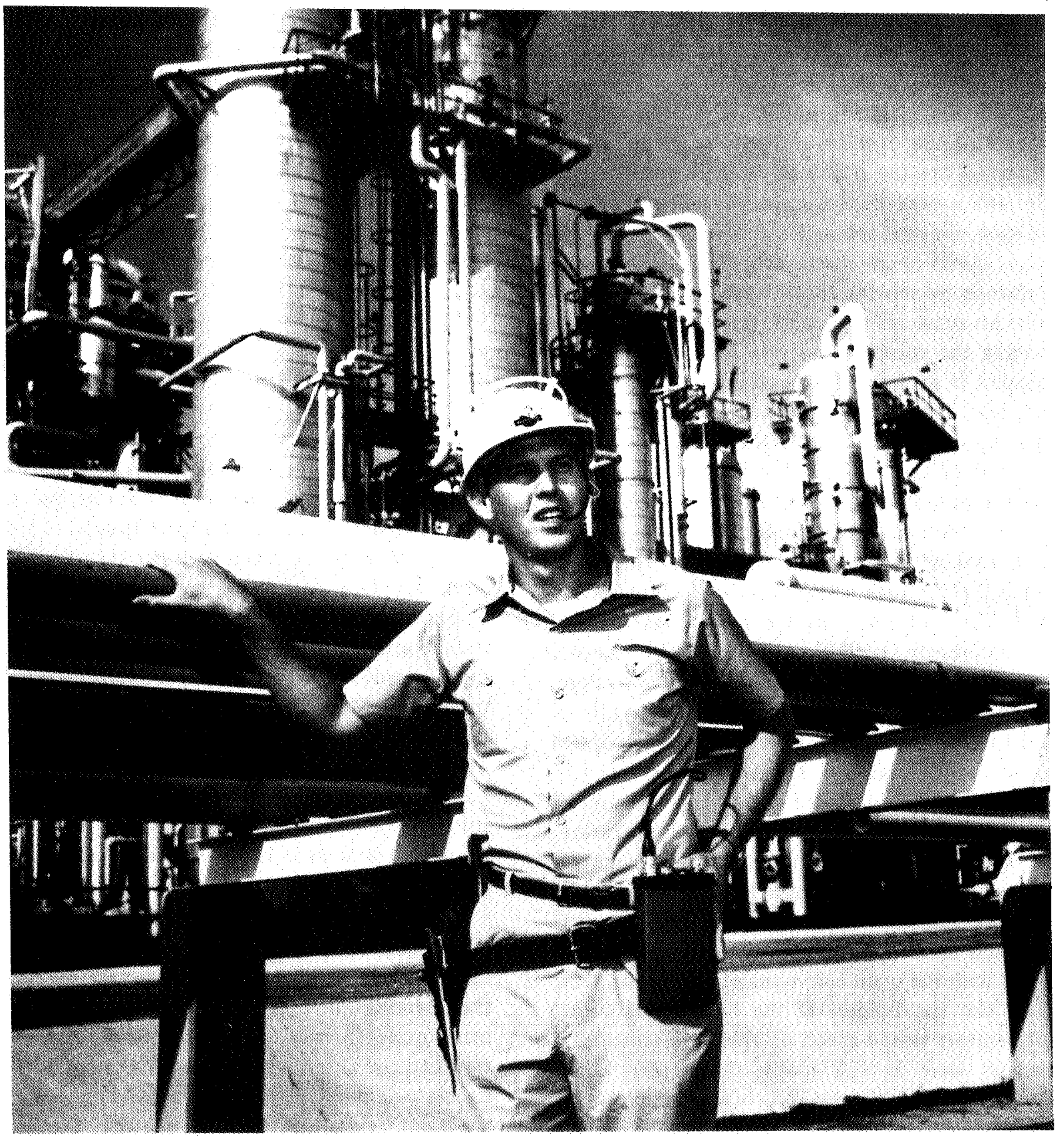
Plant Communications

In addition to improving plant performance and safety, a two-way radio system helps to mold personnel into a close knit unit that can accomplish many things together that none could accomplish alone.

K. Wright
Hill Chemicals, Inc.
Borger, Tex.



Radio communications equipment in use in a modern plant.
Photo courtesy Seismographic Service Corp.

In recent years, improved equipment design and metallurgical developments, etc. have made it possible for ammonia plants to improve their process design and throughput, and this, in turn, has generated pressure for the development of additional equipment and technology to meet these new process requirements. This situation has also encouraged advances in an important, but frequently overlooked, aspect of plant operation; communication. Communications is to plant operations what weather is the world, as it is in many ways responsible for the climate or atmosphere of the facility. The old saw that, "Everybody talks about the weather but no one ever does anything about it," has long applied to plant communications. This is no longer true, however, as the following comments will illustrate.

As a means of reviewing the interrelation of operation and communication, let us consider a methanol plant in the 1920's with a simple reforming furnace, steam-driven compressor, and a converter with a single thermocouple hung on a pulley. In this setting, you find one operator who has a helper firing the reformer and oiling the compressor. The operator's duties consist of analyzing reformer exit as on an orsat, and looking at the reformer tubes so he can tell his helper how to fire the reformer. He then runs over to the converter and moves the thermocouple up and down to find the hot spot, converts the milli-volts to degrees, adjusts the circulator compressor speed accordingly, and then tracks this change by moving the thermocouple. If he has time, he runs an orsat on the converter, but chances are that in changing the compressor steam load, he will upset his steam header. If so, he will have to adjust the steam to the reformer, reset his compressor speed, and then run the thermocouple up and down again. Now this operator is working his head off and is probably fighting a headache from the carbon monoxide that is floating around, but he doesn't have any communications problems.

Now let us look at an ammonia plant of World War II vintage. This is a plant with a low pressure steam-methane reformer, secondary reformer, shift converter, gas holder, multi-stage compressor, amine or water CO_2 removal system, copper-formate carbon monoxide removal system, booster compressor and 5,000 lb./sq. in. gauge synthesis loop with 50 ton/day converters. Panel boards and control rooms are not only relatively simple, but also widely scattered as were the operators due to the large amount of local instruments. Each area (gas preparation, purification, compression, synthesis, and utility) had a regular hierarchy of operators, senior operators, senior helpers, and helpers that were stationed in isolated areas with limited assignments. Each area functioned essentially independent of one another with the main communications means being the height of the gas holder. If the holder was rising, compressor operators would speed up their compressors. If the compressors were at full speed, the holder would continue to rise causing the gas preparation operator to adjust the feed rate. If a compressor was shut down for short term repair, very often little or no communication was required as the holder accommodated the change of rate. Twice a shift when the lab analyst ran a synthesis loop analysis, the synthesis senior operator would telephone the gas preparation area and ask for more or less air to the process. If any other activities were contemplated, the various senior operators were notified, watches were synchronized, and the remote operators given instructions. When zero hour arrived, the synchronized, somewhat coordinated, independent activities began. Fortunately, there were always plenty of vents around so if the timing was upset or anything went wrong, you would go to vent. In this case, where the communications depended on the supervisor running around and giving signals, coordination was limited and so was the production. In this system a crew of 20 men per shift would be needed for a big 400 ton/day ammonia plant.

Modern Plants

Next, consider the early 1960's model ammonia plant. It still looks a lot like the previously described ammonia plant except the pressure has been raised to 300- to 400 lb./sq. in. gauge on the reformer, the gas holder has gone, the low temperature shift converter and methanator have replaced the copper-formate system, many local mounted instruments have been incorporated in the main control panel, and the plant is arranged more compactly. There are no longer operators permanently exiled in isolated locations. Instead, they work in and out of the control room like a modernistic bee hive. The operators spend a majority of time in the control room making frequent brief trips to their assigned areas for readings, equipment checks, and lubrication. This is to make themselves available if any unexpected adjustment or event should arise. If an emergency occurs, the operators run out to carry out certain assignments and then return to the control room for further instructions. Due to the more compact arrangement of the plant, the coordination is better, but now it is the operators who run back and forth instead of the supervisor. This plant required seven men per shift for a 300 ton/day ammonia plant.

Now, we come to the large single train plant of the middle and late 1960's. These plants are built on the energy cycle premise in order to properly size the rotating machinery. Many of these plants incorporate a steam cycle that produces approximately 6,000 tons of steam/day in order to make 1,000 ton/day of by-product ammonia. Such a system has a very rapid dynamic response to any changes in steam flow. The process equipment in this style plant is much the same as in the previously described plant except that the reformer pressure is now 450 lb./sq. in. gauge, the syn loop pressures vary widely, depending on the design philosophy of the engineering contractor, and everything is much bigger. With the process response of this equipment, the operators must be closely coordinated in their work. In many cases, there is not sufficient time for the operator to travel to and from the control room or for the supervisor to circulate among the operators issuing instructions. If sufficient time is taken for the foot and mouth communication style, the momentary equipment outage becomes a drawn out period marked with erratic variations and conditions; the switching of critical pumps is an unstable system-shaking performance involving additional personnel, often at some production expense. We are now faced with the situation wherein by eliminating the process gap, we have uncovered the communications gap.

This gap has been tackled in several ways in the earlier plants. One way was, in an emergency, to call in all off-duty operators and man the plant in the same manner as in World War II. In fact, some of these plants had the instrumentation arranged to meet this condition of locally stationed operators.

Another method was to intensively train operators to understand their assignments thoroughly, and to develop ability and technique to a high level of competency. Much of this training focused on emergency procedures and developing conditoned response to different situations. The goal of this approach is to have capable operators who can perform independently should an emergency arise, requiring, hopefully, minimum communication and coordination. This approach yields good results and well trained operators are always an asset. There are several drawbacks to this approach, however. One is that the message still must be transmitted to the operator as to the nature of the problem and also, the order to initiate the procedure. The operator, in some cases, is expected to recognize the situation and proceed per standard operating procedure. Even so, he needs to notify the other operators of his action. In any event, a real possibility exists that not all concerned will get the message which could cause unrelated actions, inopportune events, and even hazardous situations. Secondly, these emergency procedures are designed with one goal in mind and that is the safe shut down of the plant. The key word is shutdown, and in any emergency this is the result. If an operator hears a loud venting sound and he guesses it's the air compressor vent, do you want him to shut down using a procedure for power failure, feed gas failure, steam failure, steam to reformer failure, boiler feed water failure, air compressor trip failure, broken tubing to instrument failure, or janitor mop handle against the instrument panel failure? You are on your way down no matter what, and how safe it is, depends on how many operators are using the same procedure. Finally, there is the basic nature of the average operator. He is an optimist. He likes happy endings and hope springs eternal no matter how bad things may look. His first notion when an emergency arises is to tough it out for another minute or two and possibly the situation will clear up or improve. After that minute or two, his thoughts then may be "It's bound to get better". By then the emergency shutdown has become an uncontrolled crash shudown hazardous for man and machines. Let's face it, an operator will expend a tremendous amount of effort, ability, and ingenuity to try and keep his unit or plant running. In his eyes, to shut down is to concede defeat. For this reason you find emergency procedures delayed for precious minutes and then proceeding at varying rates, depending on each operator's hopes of catching control of the situation at some point short of shutdown.

Telephone Network

Another method of communication in the early days of the large single train plants was the installation of a telephone network throughout the plant. This usually was sound powered system and had as many stations as were deemed necessary. If an emergency arose, a horn or whistle was sounded and the operators in the plant would run to the nearest soundproofed booth to get instructions. They would then run to the designated equipment, perform requested actions and run back to the phone booth. There were some problems encountered with this. The operator who had direct contact with the emergency often was unable to leave his station to go to the phone for some minutes, which seriously hampers the coordination. The period of time when an operator had left the phone was a similar problem. This was in part alleviated by putting long extension cords on the phone so the operator could move about somewhat and with sufficient stations maintain frequent contact with the control room. The noise levels reached during upsets and shutdowns are a serious problem though. It makes it difficult to hear the emergency alarm and hampers oral communication, especially for the control room, as the phones would transmit the area noise as well as the voice. As more experience was gained in the new plants, it became apparent that there had to be a better way to communicate.

In order to solve this problem, many people began to investigate the possibilities of various types of radio communication. They soon found a wide variety of possibilities existed ranging from citizen band walkie-talkies to elaborate business and industrial band personnel units. As there are about 26 different firms manufacturing or supplying various modes of radio communications, I won't attempt to outline the salient features of each system. Since this involves communicating with people on the move, this discussion will only be concerned primarily with portable personnel units.

A number of frequencies have been set aside for local communication under headings such as "Citizens Band", "Business", "Petroleum", and others. These frequencies are 25-55 MHz, 132-174 MHz, and 450-470 MHz. The frequency used in any specific application is governed by the choice available in the equipment offered, the frequencies currently in use locally, and coordination with existing or future radio systems. The choice of frequencies is also affected by the output power of the proposed system.

Radio Communication Systems

There are basically three different types of systems available. The first is the paging type. In this system, the operator carries a small receiving unit either on his belt or in a pocket. When communication is desired, a tone signal specific for his unit is transmitted from the base station. Upon hearing his call tone, he goes to the nearest phone to complete the exchange. Models are available that will enable him to receive a voice message giving him instructions as to action to be taken or to go to a phone, etc. This is an improved version of the sound powered phone system previously discussed. It does get away from the horn or whistle system which can be very disturbing, especially if you are next to one when it sounds off. The operator or supervisor can be given instructions without going to a phone. It can be easily interconnected with the telephone system so that many people could use it. The chief drawback is that it is only one-way and no response can be made. Also, you have no assurance that you have contacted the desired party until he calls. These units are small and light, usually weighing between 9- to 12 oz.

The next system is a simplex two-way radio system. In this system, transmission and reception are in the same frequency, although selection of several frequencies may exist. This system is widely used due to versatility. It is possible to communicate from one personnel unit to another, to base stations, or to any radio systems in the vicinity using the same frequency. These can be hand-held or worn on a belt. Ordinary usage in the prevailing noise conditions would consist of a belt unit with head set containing microphone, earphone, and connecting cable. Some units have buggy whip antennas but these are troublesome. The preferred mode is to incorporate the antenna in the cable connecting to the head set. Various noise elimination devices are used on the microphone which greatly improve communication. In this configuration a button on the belt-mounted unit is depressed to transmit, leaving the hands relatively free. When not transmitting, the receiver is monitoring the frequency. The output power of these portable units may be from 0.2 W up to 4.5 W. Their range can vary from 1- to 12 mi. The base station power may range from 3 W to 50 W, although base stations are not necessary in this system. Herein lies a problem. Because of this independence of a central station, you find these portable units often being "borrowed" for hunting, fishing, and various other activities. The base station with its higher power is needed if the control room is to have communications priority by overpowering other transmissions. Otherwise, the transmissions can be muddled when several units are trying to communicate at the same time. Units in this, and the other systems, are of the solid state, transistorized design. Their weight runs from 18- to 32 oz.

Another system is the duplex two-way radio system. Here, the portable units transmit on one frequency which is received by the base station and instantly re-broadcast by it on a different frequency that is received by the portable units. With appropriate use of satellite antenna and slave units, the power requirements of the portable transmitters are greatly reduced. Since all communication must channel through the central unit, the control room has absolute control and priority in transmission. The base unit will transmit only one signal at a time, eliminating multiple or mixed transmissions. Since the portable units cannot converse with one another without the base unit, you do not have the problem with so-called "borrowed" units. This system uses equipment similar to that previously described consisting of belt mounted unit, connected with an antenna containing cable to a headset with earpiece and microphone. An additional antenna is needed for the other frequency, and in one system this is accomplished by attaching a ring antenna to the safety hat. These units operate with power outputs of 0.1- to 2.0 W, and weigh 18- to 30 oz. The signal range would be 1/2 to 10 mi.

The power supplies available for the portable units offer several choices. Rechargeable nickel-cadmium batteries are frequently used and have several features. Rechargeable batteries usually serve for 8- to 12 hr. between charges. Replaceable alkaline dry cell and mercury batteries are also used. Alkaline dry cell service life varies from 12- to 28 hr., while mercury batteries last 40- to 60 hr. Another point that should be seriously considered is selection of radios suitable for service in hazardous atmospheres, otherwise known as intrinsically safe. Low wattage units using mercury batteries have been rated by Underwriters Laboratories as intrinsically safe and are acceptable for Class I, Group D, and Class II, Group G atmospheres.

The final consideration in the adoption of a portable two-way radio system is the licensing of the proposed system. There is nothing tricky about this and the intended vendor will give considerable help in applying for the license. There are a couple of points that need to be considered. One is the proximity to an airport, especially if it is a commercial field. This restricts the use of some frequencies and antenna heights and locations. The other is the existing radio traffic density in the desired band. If it is heavy, it may be necessary to select a different band and possibly a different model or vendor.

Although the portable radio system is the latest development in the communications aspect of plant operations, everything just isn't all beer and skittles when you're working with one. Even with solid state, transistorized equipment, you'll find Parkinson's Law in full effect. People will knock the personnel units into valves, posts, walls, and many other things, and hang cables on valve handles, fire extinguishers, bolts, etc. Frequency control will drift occasionally. Ear plugs will get plugged with wax. Microphones will get coated with tobacco juice. Then there is the stray transmission that is occasionally picked up along with the vehicle with ignition problems; and you haven't lived until you've had a crash by crash replay of a lightning storm in your ear. You'll find that you will need to devote some planning to maintenance, spare parts, and spare units. If you are not adequately staffed to do your own maintenance, then you need to locate some firm locally to maintain your equipment. Incidentally, not just any one can fix these units. If it requires expertise beyond changing batteries or repairing connections, the work should be done by licensed radio repairmen.

Advantages of Two-way Radio Systems

The impact of two-way radio systems on plant operations is very interesting. No longer are the operators and supervisor tied down to the control room or to a rigidly defined area. Instead they remain in their general area of responsibility, moving through the area, making adjustments as directed by the board operator or supervisor or coordinated with or by other operators, checking and/or lubricating rotating equipment, collecting local process data, operating stand-by equipment, performing routine safety inspections, covering portions of other operators' areas, and helping them in more strenous activities, and communicating. Each man knows where every other man is and what they are doing, with the supervisor in full control at all times. In an emergency, the supervisor can move directly to the critical point and direct the activities and assignments of his operators based on personal observation and instantaneous status reports. No longer is he forced to go to the control room to make decisions and direct operations based on what was going on a few minutes before. The system with the fast dynamic response now is being operated dynamically.

The valuable assistance of the two-way portable radios in an emergency can be easily understood. But we're not talking about something saved for special occasions where you break the glass and pull the handle. We're talking about communication; that minute by minute, hour after hour, person to person interchange that is as common and as necessary as a belt. So what can this method do for routine plant operation?

First, when operating a plant at maximum full-out rates you cannot tolerate a process upset of any kind. This requires close, continuous coverage with men available and ready to tackle or forestall any problem. You don't get this kind of coverage if they have to spend much of their time going back and forth to the control room. You don't have upsets because conditions are not allowed to deteriorate to that point. Those minor adjustments necessary to maintain optimum production are made continuously. When conditions permit operation at a higher rate, this advantageous step is immediately taken. When an operator is occupied with an item of equipment and needs a fixture, tool, etc., he need not leave what he is doing to obtain it. He may request an available operator or supervisor to bring it to him, saving time and movement. The same process applies if an operator is tied up in an operation and needs to check or adjust another unit in this area. He needs only to request a fellow operator to perform the necessary activity. So you find the result is maximum, optimum production as an accomplished, day by day fact rather than a sought after goal.

Second, the fact is that the operators in the performance of their assignments must remain somewhat isolated. This little box at their belt is one of the best protective devices they may have. If anyone is involved in an activity that may have some element of risk, no matter how small, he informs the other men so that he may have assistance or surveillance. This covers many things such as transferring or loading ammonia, lifting or moving drums, injecting chemicals, working in reformer burner area, going up on tall structures and towers to make checks or adjustments, and many others. If a man should be injured, he can call for help and get it. Fires and leaks can be reported and eliminated before serious damage or disaster can occur. In short, the two-way radio system is an excellent tool for promoting safety and for the prevention of accidents.

A third benefit is the close, cooperative relationship that is developed among the men on a shift. Although they may be dispersed through the plant, they are not alone. They easily communicate with each other, working out coordination of activities, exchanging data, helping each other to solve problems. It is as if they were in the same room with one another when actually they see each other only briefly during their shift. As they continue to communicate together, they learn what to expect from one another, and to appreciate the ability of each. The result is that these men become a close knit crew that can accomplish many things together that none could perform alone. Watching this spirit and strength develop is an exciting experience. Needless to say, the morale of such a group is marvelous.

Acknowledgement

I would like to thank C.W. Parker, General Electric Co., Communications Div., and Ben Keller, Seiscor Div. of Seismographic Service Corp. for the assistance and material aid they furnished to me.

DISCUSSION

BOB BRAGMAN, M.W. Kellogg Co.: Could you give us some idea of the number of operators you had initially, where they were placed and the number of operators per shift you have now and where they operate from?

WRIGHT: We started with five operators on a shift and still have five.

BRAGMAN: Where were they located when you started the plant?

WRIGHT: I don't know if I understand what you mean.

BRAGMAN: Well, were they all in the control house or elsewhere?

WRIGHT: No, they were out in the unit.

BRAGMAN: And are they still distributed in the same fashion.

WRIGHT: Yes.