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# Non-Intrusive Instrumentation: Key to Flexibility, Performance, and Cost Effectiveness

## One problematic element of measurement instrumentation is that obtaining a measurement usually requires intruding into the process media.

The working assumption is that there must be some sort of penetration into a vessel, pipe, or another piece of equipment to access the contents inside and obtain measurements. This means if a situation calls for the instrument to be replaced or a new one added, there must be a process shutdown to allow access to a sensor probe, thermowell, or another component related to the instrument.

But now, newer technologies make reading through metal or plastic pipe surfaces or tank walls possible, thereby measuring the process without an intrusion. This allows flexibility for process engineers to add a new measurement point on a continuous process without the need for a shutdown, pipe draining, or decontamination—and potentially additional work permits for cutting, drilling, welding, etc.—to solve a problem.

Although the range of options doesn't extend to every type of process variable, non-intrusive measurements can meet, and even exceed, the kind of accuracy expected from traditional intrusive techniques. These measurements can be used to provide a variety of improvements in day-to-day operations.

In this eBook, we will examine **six common use cases where it is most beneficial to use non-intrusive measurement technologies**, and then show how non-intrusive instruments can fulfill the requirements of each use case. We will focus particularly on four of Emerson's product families that offer non-intrusive measurement instrumentation:

**Flow —** Flexim Clamp-On Ultrasonic Flow Meters

**Temperature —** Rosemount™ X-well™ Technology

**Condition Monitoring —** Rosemount 708 Wireless Acoustic Transmitter

**Corrosion and Erosion —** Rosemount Wireless Corrosion and Erosion Transmitters and Rosemount SAM42 Acoustic Particle Monitor

These various use cases help solve operational issues, and they provide ideas for where a facility can put these concepts to work. But before we dig into the use cases, let's take a look at the benefits of utilizing non-intrusive measurement instruments.

# *Understanding the Advantages*

All of these technologies have a common element: they are designed to be installed on the outside of a process. They can also be attached to larger vessels or equipment, such as a boiler.

Additionally, these technologies share common advantages:

- **Quick installation** or servicing without costly process downtime or equipment modification
- **Flexibility** to obtain readings in many applications and environments
- **Less complexity** than intrusive approaches
- High degree of **universality** means one-size-fits-most, allowing for simpler selection and specification
- No compromise on measurement **reading quality**, meaning no sacrifice of precision, repeatability, or reliability
- **No additional safety concerns** because the potential for leak points and other hazards that occur with intrusive measurement instruments is eliminated
- **Low total cost-of-ownership** as fewer instrument types means fewer spares and simpler maintenance
- **Native *Wireless*HART® option** on most of these instruments eliminates wiring and increases portability, and an Emerson Wireless 775 THUM™ Adapter can be used with those that don't
- Some provide **continuous readings**, replacing data normally captured infrequently via manual inspections
- Non-intrusive instruments can be **specified without using costly alloys** in applications where specialty materials would otherwise be required for material compatibility requirements

# Facilitating Plant Projects, Upgrades, and Turnarounds

Some of the most critical and stressful times for a facility are when one or more units are shut down for some type of work, whether related to maintenance or improvement. Whatever the situation, there is little or no production, and management wants to get whatever is happening finished quickly and everything running again as soon as possible. Such events are typically thoroughly planned and scheduled, but some unexpected elements typically interfere and impede progress. Such are the real-world risks, and planners must prepare for the unexpected. So how do non-intrusive instruments fit into the picture?

## Risk Mitigation

There can be situations where a critical piece of instrumentation doesn't arrive on time or is mis-specified. Getting started again may call for putting something else in place to solve the problem, either temporarily or permanently, so production can resume. Where this involves temperature or flow, Emerson's Rosemount X-well Technology (Figure 1) and Flexim Clamp-On Ultrasonic Flow Meters can replace permanently installed solutions. These solutions add measurements at various points in the process, helping solve process problems.


**FIGURE 1**
Emerson's Rosemount X-well Technology can obtain temperature measurements without the need for a thermowell or process penetration.

Emerson's Rosemount 708 Wireless Acoustic Monitor may be useful for detecting the source of a process upset or bottleneck, since it can be moved from place to place to explore different possibilities. It can also be used to detect leaks, and as a flow switch.

Some existing equipment may turn out to be in worse condition than previously expected. For example, the initial plan may have been to leave some piping untouched because it was believed to be in satisfactory condition. Such an evaluation may be misinformed if there is no mechanism for evaluating actual metal thickness. Emerson's Rosemount Wireless Corrosion and Erosion Transmitters can be mounted at strategic points to evaluate those assumptions and determine what may still need attention. If this had been done previously, it could have been included as a task for the turnaround as these transmitters help maintenance teams determine when equipment has reached its end of life and must be replaced.

## Late Design Changes

Invariably, for whatever kind of project, there will be changes necessary as the work progresses. Some may be needed to correct earlier miscalculations, while others intend to capture unexpected benefits. For an intrusive solution, these late design changes often require the instrument to be re-sized and specified for the new conditions, resulting in schedule and startup risk. Non-intrusive solutions are often one-size-fits-all, so they are flexible enough to accommodate late design changes in piping size, flow rates, and other parameters.

## Cost Advantages

Often, adding an intrusively mounted instrument can be a costly undertaking, even when there is an available shutdown. For example, making a custom spool section of pipe in an exotic material to accommodate a conventional flow meter where the liquid is corrosive may be far more expensive than mounting a Flexim Clamp-On Ultrasonic Flow Meter (Figure 2) on an existing segment of pipe. Similarly, where it is necessary to add a temperature measurement, Rosemount X-well Technology may be far less costly than adding a conventional thermowell, as thermowells require wake frequency calculations and other design efforts, and welding to install.


**FIGURE 2**

There are many configuration options in Emerson's Flexim products to meet the needs of many different measurement applications.

# Expanding Coverage from Manual Inspections and Measurements

Many facilities would like to reduce the frequency of routine operator rounds, but they often persist. Some critical rounds are still necessary, and operators may have upgraded to tablets and laptops from clipboards, but personnel demographics today are driving most companies to do away with repetitive manual gauge reading and equipment inspections. Manual rounds are time consuming, expose people to potential and actual dangers, and in some cases aren't effective.

## Automating Inspections

Many manual rounds can be automated, freeing up operators to do higher-value tasks. In many environments, the challenge has been budgetary, but this makes little sense today. The cost of sending an expensive employee to read a pressure gauge twice a day is poor use of a resource. That operator undoubtedly has higher-value tasks that end up deferred at a cost to the company. On the other hand, the cost of wireless instrumentation compared to conventional wired solutions is far lower, and the range of measuring options has grown enormously. When a Rosemount 708 Wireless Acoustic Monitor is mounted on a steam trap or PRV (Figure 3), it is possible for maintenance to know when the device is leaking, losing valuable steam or product, or stuck in one position.

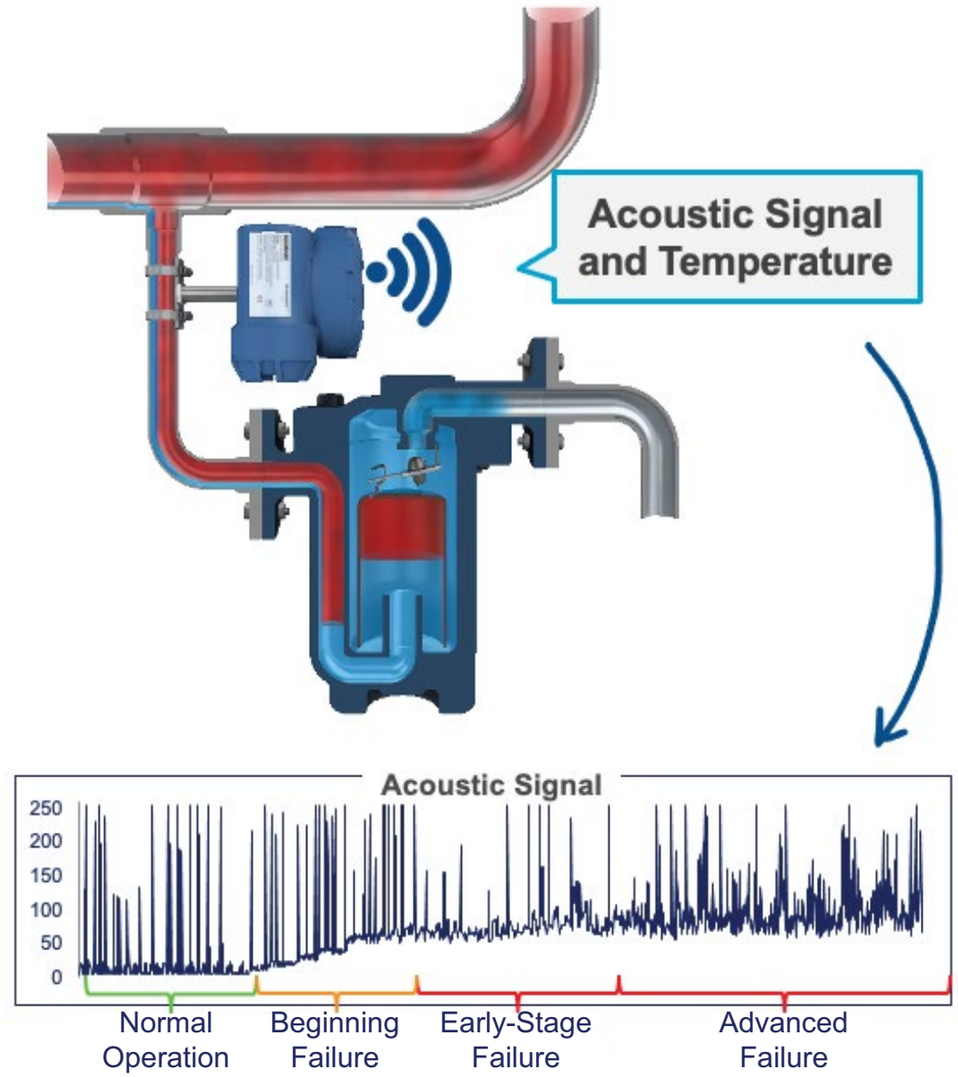



**FIGURE 3**

The acoustic pattern detected by a Rosemount 708 Wireless Acoustic Monitor, when mounted on a steam trap, can indicate a developing failure.

Emerson's Plantweb Insight™ family of software applications has a specific app for steam trap monitoring. It presents data collected from acoustic transmitters via a dashboard for an overall picture, supported by data from individual units.

This automatic evaluation is continuous and always applies the same methodology. This is not possible with human operators, as two technicians looking at the same steam trap or a PRV on different days may come to completely different conclusions as to its condition. Adding Flexim Clamp-On Ultrasonic Flow Meters to a condensate return line can also verify that the correct volume of condensate is being returned, proving that the steam system is functioning properly.

Similarly, Emerson's Rosemount Wireless Corrosion and Erosion Transmitters can be mounted at strategic points in piping to monitor metal loss ultrasonically. This type of inspection can be done manually, but in practice it is far less accurate since a hand-held device depends far too much on the operator's skill and consistency. A permanently-mounted wall thickness sensor can make far more precise determinations since it is always in the same spot, with measurements made under the same conditions.

## Filling Monitoring Gaps

Another problem associated with operator rounds is their infrequency. In some cases, scheduling limitations due to personnel availability means that a piece of equipment or an aspect of the operation does not get checked as frequently as planned. In other situations, this is made worse by operators being reassigned and rounds simply being skipped. Now a one-week interval gets extended to two, or worse. Permanently mounted sensors avoid this problem entirely.

# Safety and Efficiency: No Downtime for Installations or Servicing

Breaking into a process to install an instrument or sensor is a costly undertaking since it usually involves a process shutdown. It also has safety and environmental elements since the products involved may be hot, toxic, flammable, or all of the above. Compounding the problem, restarting a process is a prime opportunity for upsets and incidents. Consequently, managers will want assurance that such a shutdown is absolutely necessary, with appropriate economic justification.

All the products discussed so far, when applied appropriately, have the ability to forestall unscheduled outages due to equipment malfunctions or upsets resulting from a lack of process situational awareness that could have been solved with the addition of a strategic process measurement.

Similarly, all the products discussed so far can be installed without a process shutdown (Figure 4). The most complex element might call for removal of insulation, and some simple dressing of the piping to remove loose painting or filing to smooth the surface, but nothing that compromises containment. This simplifies installation enormously.


**FIGURE 4**
Since a Rosemount 708 Wireless Acoustic Monitor only requires hose clamps for mounting, there is no need for a shutdown.

# Troubleshooting and Emergency Measurements

Sooner or later in any process manufacturing environment, there will be questions related to an upset or other sudden lapse of product quality. Understanding what's going on may call for additional measurements at strategic points to supplement what the main automation host is seeing, and to evaluate possible solutions. Requesting a shutdown to install a new instrument may not be worth the time and trouble, but non-intrusive instruments solve this conundrum.

- Adding a Rosemount 708 Wireless Acoustic Monitor to a pressure relief valve attached to an upset reactor can record the number and duration of overpressure incidents
- If the flow of a product or intermediate is in question, adding a Flexim Clamp-On Ultrasonic Flow Meter can determine if a flow is out of spec
- Where an out-of-spec feedstock has serious corrosive characteristics, placing a few Rosemount Wireless Corrosion and Erosion Transmitters at critical points can quantify any metal loss as a result (Figure 5)
- If a temperature seems out of range but is not being measured, an additional temperature point using Rosemount X-well Technology can answer that question quickly

**FIGURE 5**
If process changes might increase the risk of corrosion or erosion, monitoring wall thickness using Rosemount Wireless Corrosion and Erosion Transmitters can warn of developing containment issues.

# Extreme Applications with Challenging Conditions

In some circumstances, conventional instrumentation may be at a significant disadvantage due to challenging conditions, leaving non-intrusive options more desirable.

For example, a temperature measurement using a conventional thermowell extended into a pipe begins suffering vibration fatigue due to wake shedding following a change in flow velocity. The thermowell must be extracted and replaced due to damage, but the reading is critical to avoid a process upset. Rosemount X-well Technology can replace the conventional installation, either permanently or temporarily, and provide a temperature reading without vibration concerns.

A new lower-cost source of feedstock is found to contain high solids levels that prove very erosive, quickly damaging the primary element of conventional differential pressure flow meters. A Flexim Clamp-On Ultrasonic Flow Meter can replace the existing unit and not suffer from erosion (Figure 6). Monitoring the larger effects of erosion calls for Rosemount Wireless Corrosion and Erosion Transmitters to measure metal loss.

A plan to increase production of a unit calls for higher pressure levels, operating closer to the setpoints of PRVs. A Rosemount 708 Wireless Acoustic Transmitter (Figure 7) can capture and record all the release events, both in time and duration, to evaluate potential changes required to related safety systems.


**FIGURE 6**
Where a process is too hostile for conventional flow meters, a Flexim Clamp-On Ultrasonic Flow Meter will be unaffected.

**FIGURE 7**
When mounted on a PRV, a Rosemount 708 Wireless Acoustic Monitor can detect leakage and capture release events.

Acoustic monitoring can be used in conjunction with another technology in some applications. For example, when a new well is brought online and it is producing high volumes of sand, the sand separators can become quickly overwhelmed. Operators can base their decisions on the risk component (i.e., entrained sand is present in the flow and can hinder production or cause a shutdown), but further value can be created from erosion monitoring.

This is best accomplished using Emerson's Rosemount Wireless Corrosion and Erosion Transmitters, which can be mounted at strategic points to determine pipe wall thickness. The only maintenance costs associated with this online thickness monitoring system is the replacement of batteries once every nine years or so. Mounting flexibility means that as conditions change, such as the corrosivity and erosivity of the fluids, transmitters can simply be moved by site personnel while the facility is operational.

The key benefit of an online thickness monitoring system is that a quantitative measurement of actual wall thickness is supplied, with no inferred corrosivity or baseline subtraction method. This measurement gives operators a high level of confidence in the health of the asset, and it allows optimization of operating conditions.

It is important to highlight that the loss in the pipe wall thickness is often a result of combined corrosion and erosion damage. Erosive elements or mechanisms, such as entrained sand, accentuate the damage produced by corrosion. The use of acoustic sensors enables the detection of solid particles, including sand, through their unique acoustic signatures.

As detailed below, Rosemount SAM42 Acoustic Particle Monitors provide real-time data, allowing for proactive monitoring of sand production. In combination with an online thickness monitoring system, which provides accurate measurements of material thickness, a risk and impact calculation can be derived (Figure 8). By analyzing the risk value obtained from the acoustic sensor and the impact value obtained from the thickness sensor, an overall assessment of asset health can be determined.

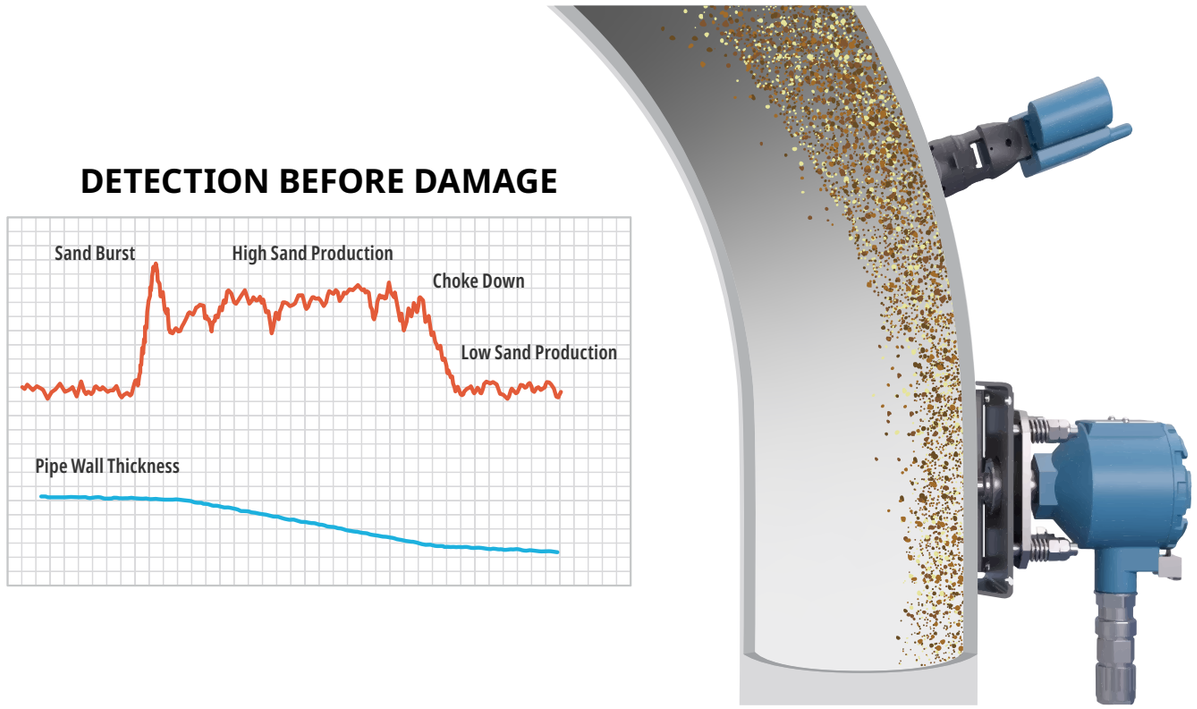



**FIGURE 8**

This conceptual representation depicts a combined solution with one of Emerson's Rosemount Wireless Corrosion and Erosion Transmitters and a Rosemount SAM42 Acoustic Particle Monitor.

Flexim Clamp-On Ultrasonic Flow Meters can operate effectively in high-pressure applications with liquids and gases, such as ethylene in a reactor inlet at 1,500 to 3,300 bar, (22,000 to 48,000 psi). The pressure is contained entirely by the pipe, so no part of the flow meter hardware has to handle it. With the addition of a Flexim WaveInjector mounting system, these instruments can make flow measurements at extremely high temperatures up to 630°C by effectively isolating the ultrasonic transducers from the hot pipe wall. Along the same lines, Rosemount Wireless Corrosion and Erosion Transmitters can handle the thick pipe walls common to high-pressure systems, and high temperatures, up to 600 °C (1,100 °F).

# Rethinking and Retrofitting Process

At various times in the life of a production unit, operators will realize that some instrument locations, determined by process designers early on, have proven not to be as optimal as originally thought. As we have seen, it is possible, and even highly practical, to relocate non-intrusive instruments, particularly those that use *Wireless*HART.

Even the Flexim flow meters designated as permanent can be dismounted and relocated without any effect on the process. This case is a bit more complex since the supporting cabling will also need to be relocated. However, an Emerson Wireless 775 THUM Adapter can be added to Flexim transmitters to provide *Wireless*HART connectivity and eliminate the need for signal wiring.

## Versatility of Non-Intrusive Instrumentation

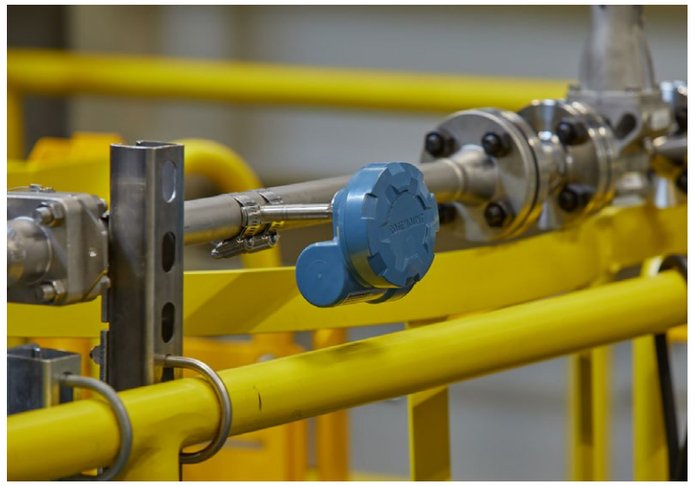
It is evident how non-intrusive measurement instruments provide ease of use, safety, flexibility, and reliability benefits for each of these common use cases, and there are many other use cases that would also benefit from these instruments as well. With the widest range of non-intrusive measurement technologies in the industry, Emerson will partner with you to help you utilize these non-intrusive instruments to optimize your processes and maintenance efforts, while reducing associated costs.

# Emerson's Non-Intrusive Product Families



Emerson's **Flexim Ultrasonic Flow Measurement Technology** offers the broadest range of non-intrusive flow instruments. Virtually anything that flows – liquids, gases, and steam – can be measured. The clamp-on ultrasonic designs enable operators to simply attach transducers to the outside of the pipe without any interruption to operation or any risk of leakage. The range of meters designed for permanent mounting are optimized for specific situations, such as the Flexim FLUXUS G831 flow meter for liquids and gases in hazardous areas. The meters designed for portable use offer quick setup for testing and troubleshooting across a range of industries and applications. This includes the Flexim FLUXUS G601 Portable Multifunctional Flow Meter, our easiest solution to measure flow and thermal energy of liquids and gases.

Emerson's **Rosemount X-well Technology** accurately measures internal process temperature without a thermowell or process penetration, so it can be installed without cutting pipes, calculating wake frequency, or a process shutdown. This reduces engineering time and total cost of ownership. It is available with a conventional Rosemount 3144P Temperature Transmitter for wired applications, or a Rosemount 648 Wireless Temperature Transmitter, avoiding the need for cabling. Various temperature ranging, sizing, and mounting options can be matched to specific applications.




The **Rosemount 708 Wireless Acoustic Transmitter** can be mounted on pipes to provide acoustic event detection of nearby steam traps or pressure relief valves (PRVs). This allows it to detect noise generated by leaks, as well as opening and closing actions. It also measures the pipe's temperature, so it can detect when the contents have changed, such as liquid to steam. It is self-powered and sends its data via *Wireless*HART, so its one-size-fits-all configuration allows it to be mounted permanently or temporarily on any size pipe.

**Rosemount Wireless Corrosion and Erosion Transmitters** are a family of unique ultrasonic sensors able to measure metal wall thickness for pipes, fittings, and vessels. These transmitters are self-powered and send their data to specialized software via *Wireless*HART, so there is no need for cabling. With the ability to measure changes as small as 2.5 microns (0.0001 inch), it is possible to historicize and chart metal loss in real time, even matching loss events to process conditions, providing the information needed to address issues.

The **Rosemount SAM42 Sand Acoustic Monitor** helps operators understand erosion risk by measuring the intensity of the solids in the process stream. It is installed at a pipe bend or elbow, and data is retrieved via the Modbus RTU protocol, delivering actionable information directly to a control or monitoring system. It provides sand intensity and rate data at a rate of once per second, empowering operators to make information-driven decisions about production output increase or decrease in oil and gas, renewable energy, and other industries.

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