WELKER JET® CONTROL VALVE

A Practical Application Handbook

Welker, Inc.
Sugar Land, Texas

November, 2000
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FORWARD

The current Welker Jet® and the earlier Jet Stream™ Control Valves are the most unique Control Valves on the market today. Over the last 44 years, Welker employees have discussed the Jet with thousands of people and users in over 15 countries worldwide. Because of its unique features and unparalleled performance, much has been said and misunderstood about this product. In an attempt to clarify some of these statements and to share the accumulated "pearls of wisdom" that have been recorded over the years, this handbook has been assembled.

A full understanding of the Jet, will give the engineer, designer, operations personnel and technician a greater appreciation for the features that the Jet presents and the performance that can be expected. The Jet can solve many problems that otherwise would create additional engineering and cost for the gas company.

My sincere appreciation to those who gave their valuable time and comments in this effort.

If you have any additional comments or input, we would appreciate your response to Welker. We trust that this booklet will be of assistance to you and your operations.

David J. Fish
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November, 2000
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WELKER JET® SPECIFICATION SHEET

Product:	**Welker Jet® Insert, Full Body and Top Entry Control Valve**
Manufacturer:	Welker, Inc., Sugar Land, Texas, USA
Function/Service:	Pressure and Flow Control of Natural Gas
Size:	1, 2, 4, 6, and 8-Inch
Flange Rating:	150, 300 and 600 ANSI RF
Pressure Rating:	1440 psig (100 BarG)
Temperature Range:	-20° F to 120° F (-29° C to 49° C)
Serial Number:	XXXXX
Date of Manufacture:	XXXXX
Material:	Casting/Forging A350 LF2 Carbon Steel, 1045 Carbon Steel, Aluminum 7075-T6 Bar
Inner Valve Material:	Proprietary Nitrile (Buna Rubber) – Compatible with Natural Gas
Diaphragm Pressure:	Maximum – 100 psig (6.9 BarG). See instruction manual
Hydraulic Fluid:	Texaco Aircraft Hydraulic Oil # 5606 G
Medium:	Natural Gas – Typical Transmission/Distribution Quality
Warranty:	Welker Standard Warranty - see Attached

Welker Jet® Control Valve

Location –

- Pipeline Control
- Power Plants
- City Gate Stations
- Transmission Stations
- Regulation Stations
- Storage Facilities
- Fuel Gas Skids
- Co-Gen Plants

Application – Sizing Program

- Flow Control
- Pressure Control
- Bi-Directional Flow Control
- Back Pressure Control
- Sequential Control
- Flow/Pressure Control with High Selector Relay Override
- Noise Problems
- Critical Control Issues
- Differential Pressure Constraints
- Rangeablility Requirements
- Positive Shut-off Requirements

Geographical Installations

United States of America

Canada

Mexico

United Kingdom

Taiwan

Australia

Belgium

Poland

New Zealand

Germany

France

Iran

Bahrain

Holland

Thailand

Welker Jet® Control Valve

Welker Engineering Company

Background:

In 1958, Robert H. Welker, P.E. was working for Tennessee Gas Pipeline Company in New York. As new pipelines were being laid and hydrostatically tested, problems with control valves were plentiful. Pipelines were filled with unfiltered stream water for the testing and then drained. The problems occurred with the sand that was left in the pipeline. As the pipeline was placed into gas service, the sand was carried along in the flow and was very abrasive to the valve sealing area. Seats were damaged and maintenance was required prematurely. Realizing that a straight flow path through the valve would be less harmful to the internals and that a hard rubber material would be more forgiving to abrasion, Bob set out to develop a valve to solve the problems that he and other gas companies were faced with.

While driving home one evening, the whole picture came into focus and the Jet was born on paper. Shortly after, Bob resigned his position and manufactured the first Jet regulator. Welker Engineering Company was founded at that moment in time. The valve design was tested in Louisiana and proved to be just what was needed for the problem. But it only took a short time to realize what had happened. The most innovative design in control valves in over 100 years had just been born. Not only did the valve resist the normal erosion, but also it was quickly discovered that it had several characteristics that no other valve had ever offered and no other valve has ever offered to this day.

Over the next several years, the valve was introduced around the world as the Jet Stream™ Control Valve and manufactured by American Singer, APCO, Texsteam Corporation and HEECO (Herts & Essex Engineering Company) in the United Kingdom. Bob went to work for Texsteam and traveled around the world promoting the Jet Stream™ Control Valve until 1970. He left Texsteam and began to pursue more innovative designs and opened his own manufacturing capabilities for Welker Engineering Company. Originally, Welker was located in Bellaire, Texas, but as the company continued to grow, it moved to Sugar Land, Texas, the home of Welker today. In the early 1970's the Jet was redesigned and became known as the Welker Jet®. It was manufactured as an insert style control valve, fitted between two flanges. In the early 1980's it was offered also as a full-bodied valve. On August 1, 1986 Welker purchased the Jet Stream™ back from Texsteam Corporation and the valve was back home to stay. In the early 1990's Bob's son, Brian, designed and developed the Top Entry version of the Welker Jet®. Production models were ready for sale in 1995. Today, all three styles are manufactured and in use around the world.

The unique features of the Welker Jet® make it truly the most unique and versatile control valve on the market today. The earliest models from the late 1950's are still in operation today. In the year 2000, the Jet begins the 43rd year of service in the gas industry. Because of the design and operation of the valve, a good understanding of the valves characteristics is a must for the engineering and operations personnel, so that they can utilize the Jet's features into their gas pipeline system.

Innovative Technological Features:

High Recovery

The flow in gas pipelines is generated by large compressor stations putting energy into the pipeline system. This energy, called potential energy and the resultant kinetic energy, is critical to gas systems and expensive to generate. Obstructions, bends, strainers, valves and other restricting pipeline elements strip the energy from the flow and decrease the efficiency of the pipeline. The Welker Jet® is a high recovery valve. This simply means that the energy, which enters the valve body, is allowed to pass through as cleanly as possible and continue to push along forward, without negative flow, through the pipeline. The kinetic energy (velocity) across the valve is returned efficiently to potential energy (pressure) in the pipeline. This is high recovery and it is important to gas companies.

With many other valve designs, much of the energy that enters the valve is spent in changing direction, overcoming internal turbulent vortices, or impinging on the valve body itself. The result of this tortured flow path is that the exiting gas has about half the energy than it did when it entered the valve. (see fig.1, fig.2 & fig.3) It is also exiting the valve in a distorted and non-uniform flow, and thus is less efficient in its attempt to travel down the pipeline. It is a bit like a person getting off of a spinning ride, stumbling around, not sure where to go or how to get there. This lost energy or direction must then be re-introduced at some point downstream if pressure and flow is to be maintained for transportation. This requires additional expensive compressor stations.

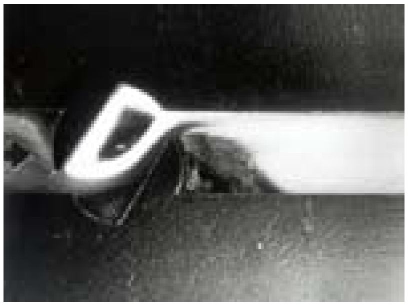

Fig 1 – Ball Valve

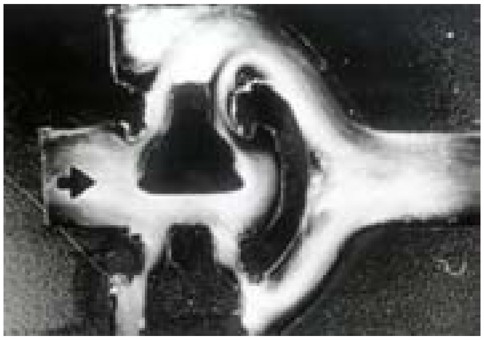

Fig 2 – Double Ported Gage Valve

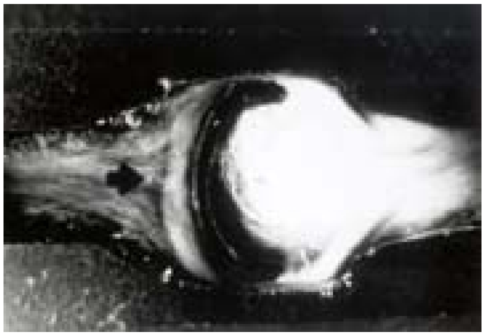

Fig 3 – Sleeve Type Valve

If the gas is allowed to pass along in a straight path, like the Jet allows, (see fig.4) without negative flow, operating expenses will be reduced and the pipeline is more efficient. The best recovery profile is the Venturi and the Jet utilizes that concept as close as possible in its design. The Jet provides high recovery of the incoming energy after the gas passes through and gives an excellent, energy efficient and developed flow profile on the outlet flow path. Less turbulence, more energy – HIGH RECOVERY.

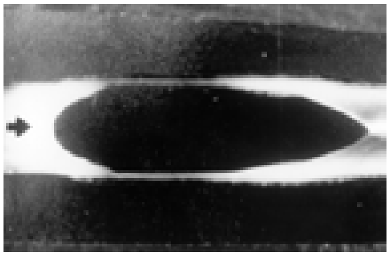

Fig.4 – Welker Jet®

Infinite Rangeability

The Welker Jet® controls the full and total capacity of its design. This is one of the most advantageous features of the valve. The claim of "infinite rangeability" has been challenged by many minds. But the fact remains that the Jet controls 100% of the capacity, from 0%, .1%, .2%, completely through to 99.8%, 99.9% and 100%. The turn down ratio is truly infinite for specific reasons. This means several things to the gas industry. ***You cannot over size the Welker Jet®.*** The 8-inch Jet can perform as well as the 1-inch Jet. If a company is designing a new station for a very large capacity in the future, but will encounter a very low capacity in the first year, it can still design the entire station for the future load. It does not have to take into consideration the low volumes at start-up, and then redesign the station later, for the larger volumes. This is an efficient and cost saving feature that many engineers do not realize is available today. This feature saves the cost of additional piping and valves, which many stations have built in, to accommodate low flows. The valve needs no special trim to accommodate this requirement, unlike other valves on the market. Its ability to fully control 100% of the total available capacity is a natural and standard feature of this valve.

This feature also means that the purchaser is buying a more versatile valve and a wider range of controllable capacity with the Jet. Remember -- *when you purchase a control valve, you are buying controllable capacity*. If you cannot control the low range and the design of the valve prohibits increased flow after reaching 75% open, even though the valve continues to open, (as is the case with most high capacity valve body designs) then you are paying for a limited capacity valve. This loss of available capacity is due to the turbulence inside the valve body that works against it achieving full capacity. The Jet offers full capacity and full control over the entire capacity. Any Welker Jet® can control a pilot light on a hot water heater or provide its maximum capacity with no special trim or modification. The hydraulic linkage responds to the slightest change in the output signal and also responds to the full range of that signal, coming from a properly chosen controller.

This feature is the result of two internal functions of the Jet. One is the straight through flow path, which eliminates negative flow as a result of internal turbulence. The other function is the action of the inner valve. The rubber plug expands radially from the center of the valve throat to the outer wall of the valve throat. Since it is expanding in 360 degrees, it is increasing or reducing the flow over the entire flow path. Unlike plug valves or differential valves, this valve has a rubber seal which makes or breaks the seal at one point of the circumference of the throat, thus allowing minimal flow or pressure to pass. Plug valves open on the whole circumference at once, while differential valves require a reasonable differential just to come open. In other words, the mechanical design of other valves precludes precise control at the low-end operation of the valve. Not so with the Jet. Therefore, since it is rubber and hydraulically driven, precise expansion and positioning is a reality. Again, this is all dependent on the quality of the controller and the parameters that have been set by the operator, whether it is a pneumatic controller or an I/P unit converting a 4/20ma signal. The Jet is only responding to the incoming signal. It has no mind of its own, no linkage driven mechanical positioner movement and no negative internal design that will offset the positive and precise action of the valve.

The net result is full flow control and full capacity control.
INFINITE RANGEABILITY!

Minimum Noise

The Welker Jet® has a straight through flow path and is inherently quiet by design. The gas flow enters the front of the valve, passes through the valve body in a horizontal path, past (across) the inner valve and exits out the back of the valve. This feature is made possible by the design of the control element and its location in the centerline of the valve body. With the gas flowing through the valve in a straight path, turbulence is held to a minimum across the entire operational sequence of the Jet, from fully open to fully closed.

Noise is the direct result of turbulence, vibration and impingement. If there is no turbulence, there is no noise. If the design of the valve takes steps to reduce turbulence to a minimum, then the noise will be limited to a minimum. If the gas flow reduces the impingement of the flow on the body or internals of the valve, then turbulence will be restricted and noise will be restricted. Conventional valves, cage valves and ball valves (except in the wide-open position) have distorted flow paths by design or during operation. They, therefore, generate noise via turbulence. A ball valve is quiet only when it is in the wide-open position, and if it is in the wide-open position, it is not controlling the flow. Noise can also generate from internal mechanical designs, where a loose trim or worn cage can vibrate and cause noise. The Welker Jet® design eliminates this possibility, as a source of noise.

There are many valves on the market that claim to be quiet, and indeed they may be. But they have added noise attenuation features that strip the valve of capacity or recovery. Another option is added body weight or noise suppressing materials that have been placed in the body structure or around the body on the outside. Some valve companies step up in size to attain the required capacity with all the noise control features that must be built in. All of this accomplishes the reduction of noise, but adds additional cost and weight to the valve or additional cost to the design of the station to accommodate the larger size valve. It may also effect the control and rangeability of the valve. The Jet's fundamental design is inherently quiet.

The noise levels of the Welker Jet® can be reduced further by design considerations such as the impact of downstream piping designs and materials, which will be addressed later in this booklet. But in its standard configuration, the Jet is a very quiet valve compared to other valves in the market. With noise levels being a major concern with most gas companies, the Welker Jet® offers a very important advantage over other valves in this critical area of concern. Engineers can head off major design problems by understanding this feature and how to use it to their advantage.

High Capacity

The Welker Jet® body design provides for a virtually turbulent free flow path. All of the available annular area in the valve is used for full and smooth flow and is not sacrificed to turbulent or negative flow. The result of this feature is a valve with high capacity.

Controllable capacity is a basic requirement for a gas control valve. A valve with high capacity and control over the full range of that capacity will frequently permit the station to be designed with smaller diameter pipe and thereby reduce the cost of construction. The Jet capacity can often meet the demand and size of a station design, where as a larger size conventional valve or two valves of another design in the same size would be required.

The design of the flow path in the Jet means that the valve will reach critical flow (the gas is traveling as fast as it physically can -- Sonic Velocity), sooner than other valves on the market. The Jet attains Sonic Velocity with the downstream pressure at 80% of the upstream pressure. In other words, the Jet only requires 20% differential to reach critical flow. Most other valves on the market do not attain critical flow without at least a 50% differential in upstream and downstream pressure. With less differential, the Welker Jet® has more capacity. In cases where upstream pressure is low and downstream demand is high, the Jet will meet the demand more readily than other valves. The Jet will achieve Sonic Velocity with a smaller pressure drop than other valve designs. Meeting capacity demands under difficult conditions is an important feature of the Jet and one that engineers can appreciate in the design stage of a regulator station and one they will appreciate even more during operation. This is frequently the case in a cold winter with maximum demand on the system and low delivery pressure. The need for gas is critical, and the Welker Jet® will deliver!

Positive Shut-off

The Welker Jet® control element is an elastomeric inner valve which allows for a positive bubble tight shut-off in the closed position. The inner valve can seal off around weld slag, small rods and many other foreign objects, which may find themselves in the seating area at the time of shut-off. The rubber will simply fill in around the item and seal against the throat of the valve. If the seating area becomes damaged, the inner valve will easily form into the damaged area and seal off tightly. Also, if the inner valve itself becomes worn due to natural erosion, the flexible and hydraulic nature of rubber will take effect and the inner valve will expand as needed to fill the void, giving continued control or positive shut-off as required. Remember, the valve is responding to set point, and not to a given position of open. If a sleeve or hard seat valve becomes slightly damaged, it will not provide a positive and bubble tight seal until the seat is repaired and in A-1 condition again. Not so with the Jet! The inner valve will still give a positive shut-off even with a significant amount of wear, damage or trash in the seat.

Quick Response

The Jet incorporates pneumatic/hydraulic linkage into the design and operation of the valve. This allows for a quick and smooth response to control signals. The virtually frictionless hydraulic system replaces the less cooperative mechanical linkage positioner systems. From a sudden requirement to close or a rapid demand for increased flow, the valve responds quickly and smoothly with no wear and tear on mechanical parts.

The quick response feature is also a positive benefit for many applications requiring smooth and fast reactions to changes in conditions. An example of this application is Power Generating Stations where the set point of the incoming pressure must be maintained within a very close tolerance and not struggle back and forth (cycle) to maintain the set pressure. With proper settings in the control signal generator, the Jet will follow the demand up and down with virtually no interruption to the downstream system parameters and tolerances.

Easy Maintenance

The Welker Jet® Top Entry is a service technicians dream valve. The inner valve can be replaced, seals checked, and the seating area checked for damage, without removing the valve from the pipeline. One person can replace the inner valve in the 8-inch Jet and place the unit back in service in approximately one hour. If he is there for an annual inspection and no service is required, he can inspect the valve and close it up in less than 50 minutes. With the new Top Entry design, most maintenance can be performed without breaking the hydraulic system. Only a major overhaul would require additional time or personnel. The smaller valves are even easier to work with.

The Welker Jet® Insert and Full Body valves can be removed from the pipeline quickly, easily and with a minimum of personnel and downtime. Two people can easily remove any of the valves, depending on the location and configuration of the piping scheme. All sizes are designed with the same basic components and with brief training, they can be overhauled in a minimal amount of time. Times will vary with installation and service experience, but a typical 6-inch Jet can be overhauled by two people and placed back in service on location within 90 minutes.

The Jet uses a minimum of seals and is designed for easy inspection and repair. Maintenance and personnel time is costly. The Welker Jet® will help to keep those costs to a minimum and provide efficient, continuous service for the pipeline operation.

Pressure or Flow Control

The Welker Jet® is used in many applications including, but not limited to, pressure regulation control, back pressure control, flow control, sequential control, bi-directional control, active and monitor, active and standby and others.

The Welker Jet® is truly a versatile control valve unlike any other valve on the market in the world today. It is a true CONTROL VALVE (maintaining outlet conditions/setpoint, regardless of inlet pressure changes), not a conventional pilot operated regulator, or a pressure regulator (outlet conditions/setpoint changes with inlet condition changes). A Gas Industry engineer designed it for the Gas Industry. It is typical of the innovation for and commitment to the Gas Industry from Welker Engineering Company - - - "Designing the Future – Worldwide"

ENGINEERING NOTES AND CONSIDERTIONS

Capacity Considerations -

Capacity and control of that capacity is critical when dealing with a pipeline control valve. Understanding the features and capabilities of the valve that you are going to use in your station will allow you to design a quality installation and keep your costs at a minimum. In any given size, the Welker Jet® capacity is only exceeded by a ball valve in the wide-open position. This benefit allows for better station design and development, and for future demands at the station. Having infinite rangeability along with the superior capacity, makes the Jet a designers dream.

Listed below, in no particular order, are important considerations regarding the impact of the Jet in areas of capacity. The words in **bold print**, are the key words of interest when quickly looking for a particular issue.

- You will realize better capacity if you stay with the same **pipeline size downstream** of the valve for 40 pipe diameters before increasing the pipe size. Downstream turbulence will strip the valve of capacity. (see fig.5) A WJ-4TE or WJ-4NF in 4" pipe will have more capacity than a WJ-4N, WJ-4NF or a WJ-4TE into 8" pipe. Velocity profiles are inclined to become uniform after approximately 40 pipe diameters of same size piping.

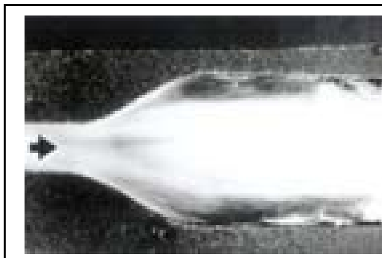

Fig.5 – Expansion Turbulence

- Boundary layer separation, vortex action, negative flow and negative velocity all equal turbulence and consequently noise and **poor capacity**. A good valve body design, a valve with high recovery and proper downstream piping configurations will reduce the impact of these negatives and should and can be addressed at the engineer's drafting table in the design stage.

- When placing **regulators in series**, as in the active and monitor configuration, distance between the regulators is key. The effect of the upstream (monitor) regulator in the wide-open position, on the downstream (active) regulator is important to know. Due to the superior flow path of the Jet and the high recovery, keep the following distances in mind during design.

Back to Back	25% capacity is lost
With 15 pipe diameters	10% capacity is lost
At 40 pipe diameters	Negligible capacity loss

  Turbulent flow can be a cause of capacity loss. The objective is to get controllable capacity across the station and the Jet will out perform any other valve on the market in this task.

  Compare these numbers to other valves, before you make a choice. Most manufacturers do not even address these capacity issues with valves in series, due to the poor performance rating that would result. The high recovery feature of the Welker Jet® adds value to the valve for engineers and performance of the station's capacity.

- Always plan for 30% **more capacity** than you will need. Any number of things can affect the output of any valve. Hydrates, piping, gaskets, weld beads and other things will create less than perfect flow paths and thus cause turbulence, which in return, affects capacity. And in the future, you may need just a little more volume than the original design called for, and it will be great foresight to have it available. In most cases, the Jet will be giving you this extra capacity feature already, size to size over other valves. As mentioned before, you cannot oversize the Welker Jet®.

- Incorrect sizing for downstream piping or an inappropriate piping scheme downstream of the valve can cause as much as 30% **lost capacity** from the valve, and it will not be the valve's fault. It will be the result of aerodynamic loss due to turbulence. This aerodynamic phenomenon is also a major source of noise, as well as lost capacity.

- **Fixed capacity control** is accomplished in the Jet with restrictive liners or restrictive stress rings. Where the downstream limitations are exceeded by the capacity of the valve, a fixed percentage restriction is placed in the valve, so that even in the wide-open position, the valve will only pass a certain volume of gas. These restrictive devices are discussed in the technical manual for the Jet. They present no negative side effects.

Velocity Considerations -

Velocity is an important issue in the engineering and design of a control valve and measurement station. Due to certain standards imposed in different regions and countries, velocity can either be a non-issue, or it can be a very serious and costly concern. Understanding and handling the velocity can enhance or destroy a station's performance. Many attempts to control velocity actually create more negatives than people realize. Here are a few considerations, with the key element in **bold print**.

- When passing through a control valve, you want to get velocity (Kinetic energy) back to pressure (potential energy) as quickly as possible. **High recovery** design is the key to this issue.

- You cannot *control* velocity for approximately 40 pipe diameters downstream of a valve. Even by increasing the pipe size immediately to slow down the flow, you cannot **control the velocity** for 40 pipe diameters. (see fig.5) The velocity profile does not stabilize that quickly coming out of a valve exit due to the turbulent flow. There is one exception to this, and that is the **Venturi** fitting or Venturi angle. (see fig.6) A full Venturi will have full (96%) recovery (i.e. constant velocity profile) at its outlet. However, Venturi fittings are very expensive and therefore seldom used in piping schemes.

Fig 6 – Venturi Fitting

- When considering larger pipe downstream for **slowing the velocity** of the gas, remember that the WJ-N style valve is already going into a larger pipe size, by design. The WJ-N style is a particular valve size that is installed and fits into the next larger pipe size. Example: The WJ-4N, a 4" valve, fits inside 6" pipe. Even with the WJ-NF and the WJ-TE, the piping downstream is a step up. The WJ-4NF and WJ-4TE annular area is 5 in^2, and 4" pipe is 12 in^2.

- Slowing down the gas flow is not considered for the sake of speed alone. Slowing down the gas speed is desirable to reduce noise and turbulence in piping configurations. It may also be a requirement for measurement equipment, i.e. Ultrasonic Meters (See Noise Considerations – Velocity Profiles). If you have a good flow profile from your valve and limit the rate of expansion with a good piping scheme, you will have the desired flow path downstream, and **slowing down the gas** may not be critical.

- **Velocity/Speed notes:**

  - Mach 1, the speed of sound, is 1100 feet per second (335 meters/sec) or 720 mph (1159 km/hr). The speed of sound is **sonic velocity** and we also refer to it in the control valve industry as, **critical flow**.

  - 200 feet per second (61 m/sec) velocity is normal in the USA.
  - 45 feet per second (15 m/sec) velocity is a European norm.

Noise Considerations -

The question of noise is a very serious one and more stations are being reviewed for noise because of living and working conditions as well as the mechanical stress factor that noise places on the structure of the piping.

Noise can be measured in the by dBA levels (decibels). Some regions use phons, while others have different methods for noise determination. For the purpose of noise in regulation stations as it relates to valve noise, here are some simple points to remember. The **bold type** will highlight the key issues listed below.

- Noise formulas for the Industry provide approximate **estimates of predicted noise levels**. Real life figures may not resemble the mathematical results from the computer screen.
- dBA levels are a logarithmic function. For every 3 dBA rise or fall in the noise readings, the **noise level to the human ear** either doubled or decreased by one-half.
- Most **noise level readings** for control valves are taken 3 feet (or 1 meter) downstream of the valve and 3 feet (or 1 meter) perpendicular to the pipeline flow.
- The noise level **decreases with distance**. As you move away from the pipeline, the natural dBA reduction will be 1-2 dBA for every six to seven feet (two meters).
- Many **noise level requirements** are set for the property line of the station rather than at the valve itself. The important question to ask is, - "Where is the noise level to be measured? At the valve, at the fence line, at the property line, or where?" The formula driven predicted noise levels are for 3 foot by 3 foot from the valve, as described above.

Other notes:

- Several things are **contributors to noise**. Boundary layer separation, vortex action, impingement, negative flow, piping elements, bends, turns, restrictions, raised gaskets, weld beads, vibration – all equal turbulence, and consequently noise and reduced capacity. Mechanical vibration (worn or loose parts) is also a source of noise. All of these elements should be thought of during the design of a station so they do not have to be dealt with out in the field after start-up.

- Most valves have a torturous flow path and therefore use a diffuser to reduce the **inherent noise** coming from the valve design. The Welker Jet® uses a diffuser to make it even quieter than it already is by virtue of its design. The Jet has a natural inherent noise level of approximately 90 dBA, with no noise attenuation trim at all.

- Perhaps the most significant step to take for noise reduction is to use **heavy schedule pipe** (Sch. 80 or higher) for at least 40 pipe diameters downstream of the control valve. Sch. 80 pipe is worth 4-5 dBA, but also adds other benefits to the system. If possible, take the heavier pipe all the way to under the ground level. The money spent for Sch. 80 pipe must be weighed against the cost of diffusers, larger valves, larger pipe and other measures taken to reduce the noise. Noise, vibration, station design stability and such are all benefited from this simple step.

- A **perforated diffuser** is designed and installed for the purpose of noise reduction. The diffuser produces a constant velocity profile by breaking up the hard plume of gas exciting the control valve. This reduces the high velocity turbulence thus reducing vibration and noise. It is basically putting the brakes to the exit gas velocity and then is creating a new velocity profile at a slower speed. (see fig.7)

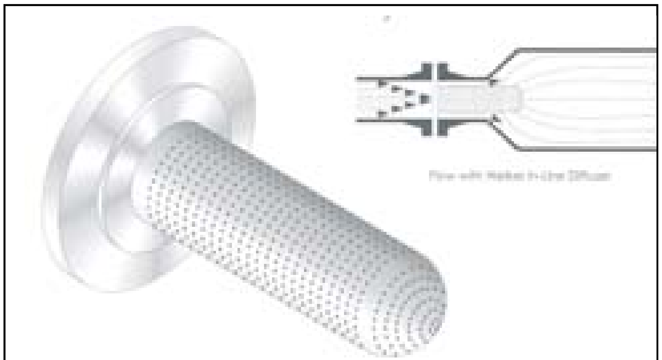

Fig 7 – Perforated Diffuser

- Diffusers are designed to reduce noise levels, and do so by dealing with the creation of altered **velocity profiles.** Diffusers can be successfully designed and used to create flow profiles for measurement meters, such as Ultrasonic Flow Meters, by slowing down the gas velocity.

- Before a diffuser is considered, consideration should be given to the pipe schedule and piping design. The Welker Jet® is very quiet to begin with. **Serious noise problems** are almost always the result of downstream piping and not the Jet itself.

- A standard Welker In-line diffuser will reduce noise 7-10 dBA with a 5-10 psi (.3 to .8 Bar) **pressure differential**. The greater the differential, the greater the noise reduction that will be provided from the diffuser. A 10+ dBA noise reduction can be expected with differential pressures exceeding 15 psi. You can expect a minimum 10 psi pressure drop across a diffuser.

- In the installation, the **diffuser location** should be after the active or second valve, not after the monitor or first valve.

- It should be noted that a **diffuser will reduce the capacity** of any regulator. As a rule of thumb expect the valve to have a 20-25% rated capacity reduction with an in-line diffuser. The greater the differential, the greater reduction in noise, but, also a greater reduction in capacity.

- **Noise attenuating blankets** are also a good method of reducing noise and generally speaking, will lower the noise 10-15 dBA. They should cover the valve spool and 4-15 feet of the downstream piping and are simple to install.

- **Silencers** deal with noise, with little or no concern for velocity profiles. This is true for sieves and filters as well. A silencer is generally good for 16-20 dBA, but at a large cost to capacity and recovery.

- A noise reduction of up to 20 dBA can be accomplished by designing the station so that the control valve exit flow is aimed into the ground on a 45° angle. This is **directing the flow underground** prior to the first bend in the piping and taking the noise under ground. You then need to stay underground for some distance, to keep the noise muffled. On rare occasions, some noise that is generated underground can and will travel backwards, up the pipe into the station.

- In a majority of cases, if you attain a noise level reduction to 70-75 dBA, you will have sacrificed capacity and **lost performance** under the worst operating conditions for your station. The Jet will give you the best performance because of the high recovery and the fact that it took less modifications to get to 70 dBA than with other valves.

- Differential pressure, i.e. **pressure drop**, can be a source of noise. The greater the differential in pressure, the more noise that is potentially generated across the valve.

Piping Considerations -

Piping and its impact on the station performance is often overlooked in the design stage. These issues actually carry a significant role in the final success of a high performance station design. All the positive features of the equipment choices can be stripped away by poor piping selection and design. Many times, property limitations will dictate piping design, but with an understanding of the piping's impact on the station, you can design a good station in a constrained space and not give up performance. The **bold type** will highlight the key issues listed below.

- **Incorrect sizing** for downstream piping or an **inappropriate piping** scheme downstream of the valve can cause as much as 30% lost capacity from the valve, (90° elbows alone, can cut capacity as much as 10%) and it will not be the valve's fault. It will be the result of aerodynamic loss due to turbulence. This aerodynamic phenomenon is also a major source of noise, as well as lost capacity.

- Piping is an important consideration with the Welker Jet®. Because of its positive exit flow profile and high recovery, downstream piping can inadvertently become a noise generator. A **90° elbow fitting** immediately downstream can generate high noise because of the flow, -- but the noise is the result of the gas impinging on the elbow, and NOT from the valve itself. (see fig.8)

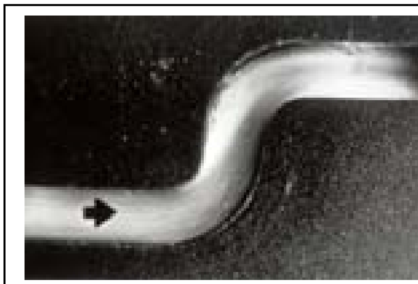

Fig 8 – Elbow Flow Path

- The best recovery profile for piping is **a Venturi**. You want to try to match that profile in your valve and piping design as closely as possible.

- Even by **increasing the pipe size** to slow the flow down, you cannot control the velocity and velocity profile for 40 pipe diameters downstream of the exit of a control valve.

- If you are going underground, use **a 45° fitting**. (see fig.9 & fig.10) It will reduce noise and provide a much better flow regime for efficiency. Allow at least 10 – 15 pipe diameters downstream of the valve before the 45° bend to go underground. Still use XH pipe in the design parameters for the exit piping scheme for 40 pipe diameters.

Fig 9 - 45° Elbow Flow Path)

Fig 10 - 45° Piping installation

- The natural recovery and stabilization of the flow profile takes approximately **40 pipe diameters** regardless of the type of valve or fitting that created the turbulence. This is a constant, not an arbitrary figure.

- Inlet piping is not as critical in design as **exit piping**. Spend time thinking and designing the exit piping scheme to take full advantage of the control valve's exit flow path.

- Use the **same pipe size** as the valve or no more than one size larger, for 40 pipe diameters downstream.

- When using **reducers** to increase pipe size, a tapered reducer is preferred over a concentric reducer.

- **Slowing down the gas velocity** is intended to reduce the noise and turbulence in piping configurations. If you can control the design of good downstream piping, slowing down the gas is not critical. If you jump to larger sizes in an attempt to slow the gas down, you cause turbulence from vortex action and create additional noise. This negative result can be controlled with a better design. While expansion will help slow the gas down, it also allows for negative flow, noise, slower recovery and other negative factors in end.

- A Better Flow Path =
    - Better noise levels
    - Better recovery
    - Better capacity

- Flow predictions, noise predictions and other **anticipated performance criteria** for a given station vs. the true results in the field, depends solely on piping configurations. Piping can destroy all the positive design features of a valve, especially an aerodynamically clean valve like the Jet Stream™ or the Welker Jet®.

<u>CLUES FOR CONTROL PROBLEMS</u>

- Are there other regulators close downstream?
- How much volume do you have downstream?
- Is there a Butterfly or Check Valve downstream?
- What is the scale (element) of the Controller? P1 or P2?
- Where is the sense point? Turbulent or calm area?
- Have you adjusted the Gain/Integral Band (Proportional Band)?
- Small diameter tubing for a sense line? Should be 3/8 or larger.
- Do you have the highest quality of conditioned instrument supply?

GENERAL ITEMS OF INTEREST

- Typical **pipeline quality gas** has less than 6 to 7 pounds of water per one million standard cubic feet of gas. That is considered to be "dry gas".

- 1,000 standard cubic feet of gas is shown as – **m**

- 1,000,000 standard cubic feet of gas is shown as – **mm**

- **Cv** is a liquid coefficient – the amount of water at 60° F, which will pass through a fixed orifice in 1 minute.

- **Cg** is a gas coefficient.

- **C1** is a streamline factor. The lower the better in a valve design.

- **Differential pressure loss** in piping between the active and the monitor valve is minimal with the Welker Jet®. The monitor will have a differential pressure loss which may be calculated. Any additional pressure loss will be from turbulence, but it will be slight. Remember that you always have some pressure loss from the piping alone, regardless of the other considerations.

- To figure the **differential pressure of a valve wide open**, get the minimum design P1, and the maximum design capacity needed, and the maximum design desired differential pressure. Subtract design DP from P1 and call that P2. Solve for Q in the Jet Formula. Backup or go forward to desired flow rate. When you hit your desired flow rate, you will have the Differential pressure drop of the valve.

- When you pick **the scale (Element) on a controller**, think P2, and not P1. Relief valves are for P1. Get the controller with the correct scale. Not mid-scale and not low scale. Your control will only be as good as your selection of controller and scale.

- In **sequential control**, two or more regulators with **reset (integral) controllers** will not flow consistently into a common discharge. Reset senses $1/10^{th}$ psi difference. You cannot set the controller <u>exactly</u> the same, so -- one reset will not be satisfied and tries to adjust, and vice-versa, and etc. They will fight each other. Only one should have a controller with reset. The other(s) should not.

- You cannot **control pressure and flow** at the same time, with one valve. Flow control with pressure override can provide for both aspects of control, but only one or the other will operate the valve at one time.

- **Critical flow** occurs when sonic velocity is attained. At this point, regardless of upstream conditions, no more flow/capacity can be produced.

- To determine what size control valve to use, think only of the **worst flowing conditions** that the valve will experience. This worst condition would be at the lowest inlet pressure (P1) and the highest outlet pressure (P2) required, for the maximum capacity needed downstream.

- **Control Valves** operate from a signal from a controller, and respond to set point regardless of inlet pressure changes or flow changes.

- **Pilot Operated Valves** vary delivery with changes in upstream pressure and load changes. They are placed in operation for one set of conditions. If conditions change, they must be adjusted for those conditions. They do not have great capacity.

ITEMS RELATIVE TO THE WELKER JET®

- The **controller or control system** is a very important part of the Welker Jet® package and function. Choosing the right controller and the correct features for the job will be a vital key to the successful operation of the installation and to provide for optimum usage of the flexibility and versatility of the Jet.

- Remember that the Jet is a Control Valve, not just a regulator, and as such is **operated by a controller**. It is not operated by a positioner. The controller determines the pressure or flow parameters, not a handle or a positioner set a 25% open. The controller has a set point and it will operate the Jet to satisfy the set point, regardless of the percentage of open or closed that is required.

- The Welker Jet® is a valve that is **totally responsive to the signals** it receives from the controller. This is a unique feature of the valve. If the Jet is not acting correctly, it is most likely that the controller that needs adjustment, not the valve or the valve design. The Jet simply does what it is told to do, smoothly and quickly, from bubble tight closed to 100% wide open. There is nothing negative in the design of the Jet that has to been overcome or designed around.

- The Jet valve is **linear**, from open to close. It is not always repeatable in its linear action due to the hydraulic fluid levels and the durometer of the rubber inner valve. Therefore, you cannot rely on the position of the indicator rod as to the percentage that the valve is open or closed. If the fluid level has dropped slightly, the accuracy of the indicator rod has moved slightly from the original point. When you change inner valves, the durometer will vary slightly from the previous one, so the position of the indicator will be different from the previous inner valve. But, it is still linear relative to the slightly reduced fluid level or the new inner valve.

INSTALLATION NOTES FOR THE WELKER JET®

- The Welker **technical handbook** for the Welker Jet® will provide information for most typical installations.

- For the best control signal, the **sense point** should be in a tranquil location with a good, steady flow profile across the pipe diameter. A good location for this, is the piping that is leaving the station. A sense point in a header or at the exit of the valve may not be the optimum location. If the sense point will not give an accurate signal, then the controller and the valve will never be able to provide optimum performance.

- If you know that you will encounter turbulence at your available sense point, don't overlook the usage of a **Pizometer ring** to obtain a good sense point signal.

- All **hydraulic tubing runs** should be kept as short as possible to assure quick response to signals and to eliminate most difficulties in the field with the vacuum and filling of the hydraulic system.

- The **Monitor** regulator should always be installed upstream of the **Active** regulator.

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