Gas（Oxy-fuel) Cutting / Gas Welding

Classification of gas

Combustible Gas --- Combust with heat and light by being mixed with air or oxygen.

Acetylene, Propane, Hydrogen, Methane, Propylene, Butane, Ethylene

Combustion Supporting Gas --- It doesn't combust or explode by itself, but supports combustion. It has possibility to cause explosion when it be ignited as mixed gas with Combustible gas.

Oxygen, Nitrous Oxide, Air

Noncombustible gas --- Not only non combustible, but also distinguish flame.

Nitrogen, Carbon Dioxide, Argon, Helium

Gas（Oxy-fuel) Cutting / Gas Welding - Gas types

Combustible Gas ･･･ Acetylene, Propane, Methane, Hydrogen etc.

***10% or lower Flammability Limit in air**

***20% or higher difference on maximum and minimum Flammability Limit.**

***Generally, HC gases are used as fuel gas in Oxy-fuel gas cutting.**

HC: Hydrocarbons: A Type of Organic Compounds from Carbonium atom (C) and Hydrogenium atom (H).

Noncombustible Gas --- Helium, Argon, N2, etc.

***Generally, there is not much chemical reaction for Noncombustible Gas. Noble gas compound doesn't create chemical reaction and known as pronoun of Noncombustible gas. Helium and Argon gases are included in this category.**

Also, gas that are difficult to create chemical reaction such as Nitrogen is considered Noncombustible gas in welding / cutting industry.

Gas（Oxy-fuel) Cutting / Gas Welding - Gas types

Combustion Speed

		Methane	Acetylene	Ethylene	Propane	Hydrogen
Chemical formula		CH_4	C_2H_2	C_2H_4	C_3H_8	H_2
Molecular mass (g/mol)		16.04	26.04	28.05	44.10	2.02
Specific Gravity (15℃ 1atm)		0.55	0.91	0.97	2.01	0.07
Density (15℃ 1atm)		0.68	1.11	1.195	1.90	0.084
Mixing Ratio (O_2)	Theory	2	2.5	3	5	0.5
	Neutral	1.6	1.1	2.0	3.75	0.25
Combustion Speed (m/sec)	Theory	4.1	10.1	5.0	3.3	10.7
	Neutral	3.8	7.2	4.5	2.7	9.1
Temp. (℃)	Theory	2787	3076	2909	2829	2814
	Neutral	2780	3110	2909	2806	2560

Neutral Mixing Ratio is different from Theory Mixing Ration and it is considered that this is because of the reaction with oxygen in air.

Theory Mixing Ratio is ratio of combustible gas to make Carbon Dioxide and Water by oxidizing the combustible gas.

If it is Propane, $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$,

and Theory mixing ratio is Propane (1) : Oxygen (5)

Gas（Oxy-fuel) Cutting / Gas Welding - Gas types

Oxygen

Combustible Supporting Gas --- Oxygen, Nitrous Oxide, Air

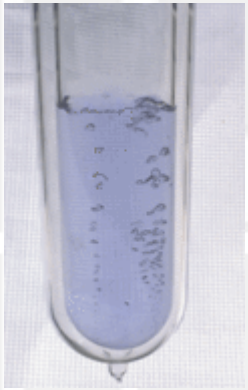
Gases that makes oxidation and helps materials to combust.

In general, it is about gases that enhances combustion more than air.

Property of Oxygen

Chemical formula	O_2
Molecular mass	32.00
Gas density	1.429 kg·m^{-3}
Specific Gravity (compare to air)	1.1
Boiling point	50.35 K -218.79 ℃
Melting point	90.18 K -182.95 ℃
Latent heat of vaporization	213 kJ·kg^{-1} 50.9 cal·g^{-1}
Specific heat	920 J·kg^{-1}·K^{-1} 0.219 cal·g^{-1}·℃$^{-1}$

Temp. 0℃(273K) Pressure 1atm(10^5Pa)



Liquid Oxygen

Industrial Usage

1）Chemical synthesis
2）Decomposition of Impurity
3）Creation of high temperature
4）Oxidation of organism（Sewage treatment）

Oxy-fuel cutting performance and safety

Human body and oxygen concentration in air

~100% High Oxygen Toxicity
Convulsion, Dizziness, Disgust, Confusion, Hallucination, Visual Impairment, Pain in Toe

~46% Limit for short-time breathing

~36% Limit for long-time breathing

18~25% Appropriate density

17% Initial Hypoxia

12~16% Headache, increasing pulse

6~10% Unconsciousness, issue on central nervous system, convulsion, stop breathing and die in 6 – 8 minutes.

~6% Faint in one breath, stop breathing, convulsion, and die in 6 minutes.

Materials that don't combust in air could have intense flame in oxygen. This is a very dangerous situation in high temperature thermal cutting.

Gas（Oxy-fuel) Cutting / Gas Welding
- Gas types

By Gas State

a) Compressed Gas ･･･ Filled in high pressure tank by high pressure such as 14.7MPa or 19.6MPa (35℃) in Gas State 。

***Oxygen, Hydrogen, Methane, Nitrogen, Argon etc.**

b) Liquid Gas --- Pressurized under normal temperature and filled in tank as liquid

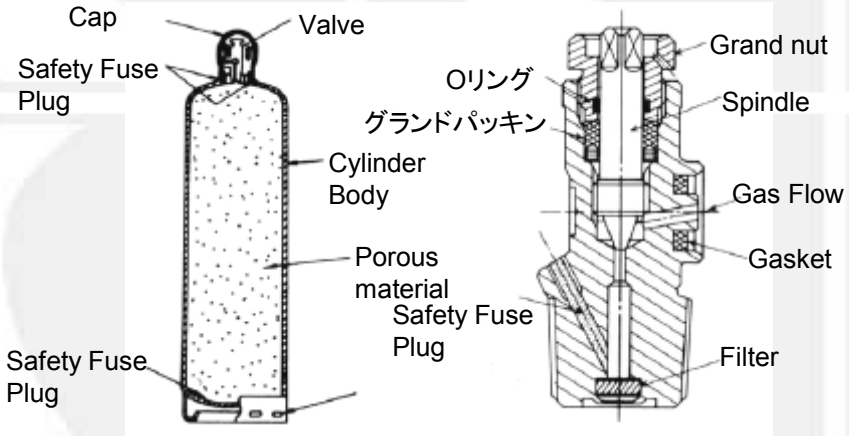
***LP Gas (GLP)**

--- Pressured and filled in tank under super-low temperature as liquid.

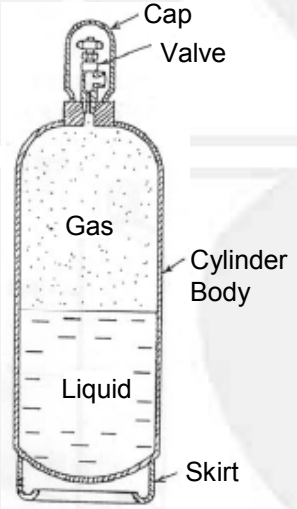
Liquid oxygen, LNG, Liquid Nitrogen

C) Dissolute Gas --- Pressured and filled in tank with solvent (Acetone, DMF)for safety .

***Dissolute Acetylene**

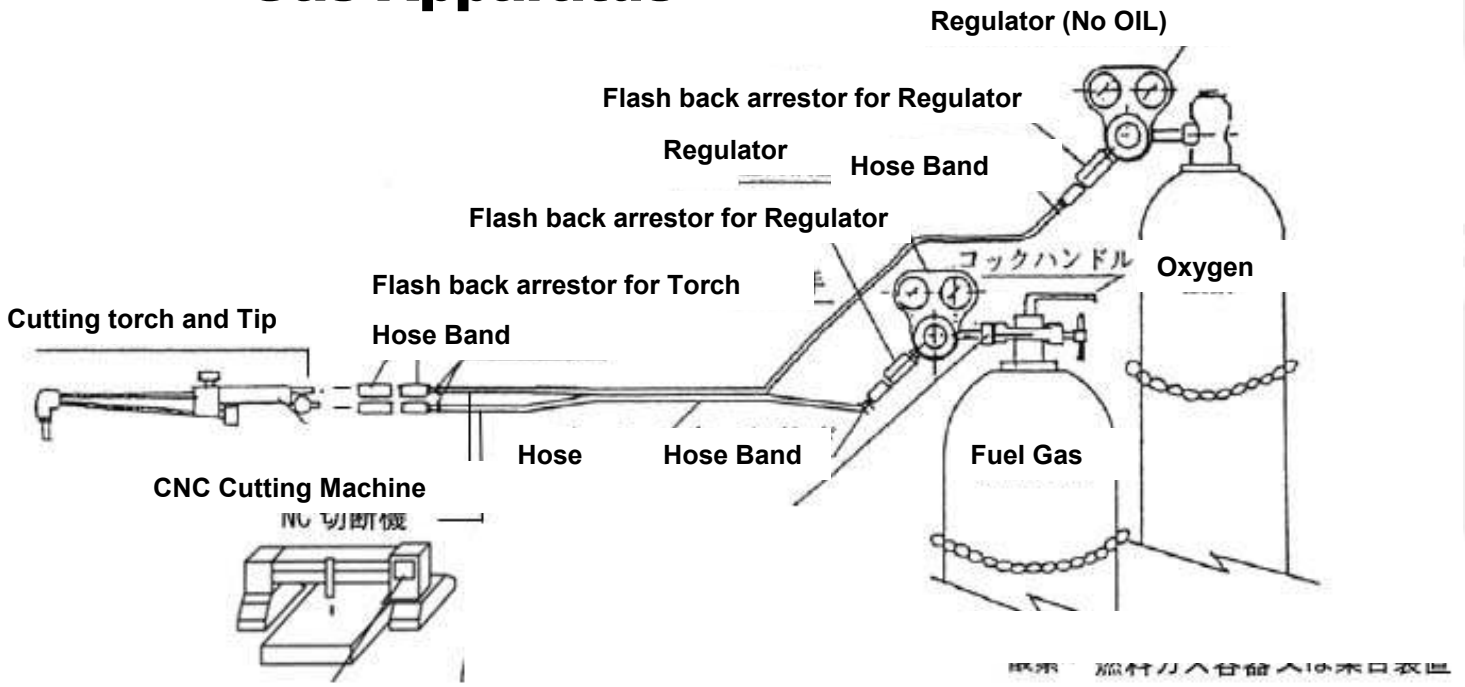


Dissolute Acetylene Cylinder



LP Gas Cylinder

Gas（Oxy-fuel) Cutting / Gas Welding - Gas Apparatus



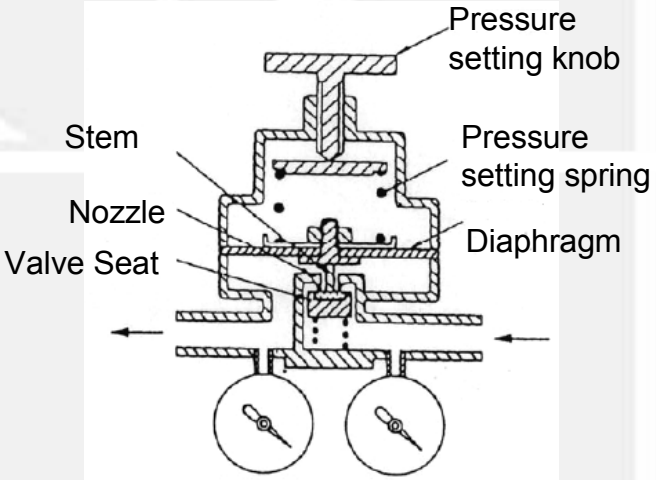
Use appropriate Gas Apparatus from gas supply to cutting point, based on property of each gas.

For example, Oxygen Regulator are oil prohibited apparatus.

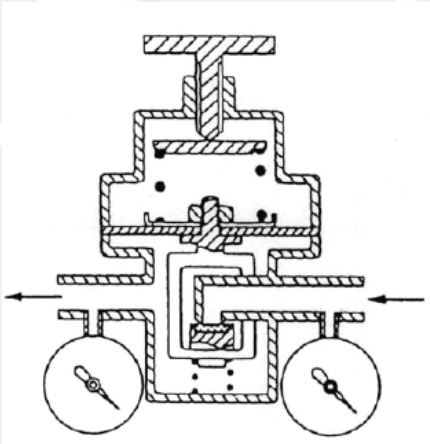
Gas（Oxy-fuel) Cutting / Gas Welding - Gas Regulator

Oxygen and Fuel Gas are supplied from Cylinder or Gas Manifold through pipe/tube/hose.

Generally, gas pressure from supply side are much higher than the gas pressure required at use point, and need to regulate the pressure to make sure correct cutting operation. Also, it is dangerous to use cutting torches in higher pressure than needed. This is why we use Pressure Regulator so that to reduce the pressure to be used at the best pressure at the cutting torch.



One Stage



Two Stage

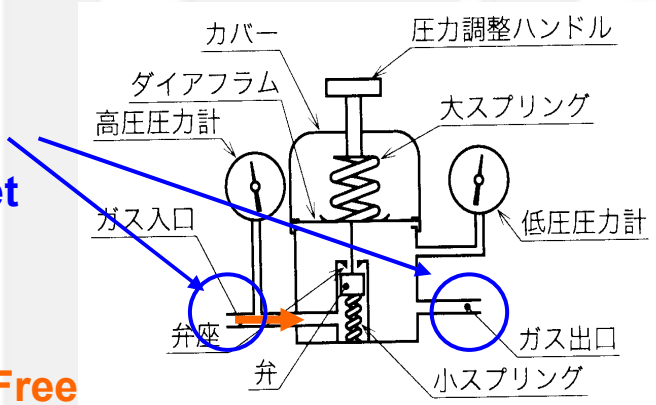
Gas（Oxy-fuel) Cutting / Gas Welding
- Gas Regulator

・How to use Gas Regulator

1) Don’t use the equipment with hand (or globe) that has oil stain, and don’t use grease or oil at any part of the regulator.
2) Don’t let dust getting into the regulator.
3) Don’t attach the regulator when it is difficult to attach to the cylinder.
4）Attach the regulator so that the gauge are facing the correct direction.
5）After attaching the regulator, loosen the pressure adjustment handle of the regulator counter-clock wise, and open the cylinder valve. (Avoid adiabatic compression)
At this time, you can not stand in front of the regulator.
6） Exchange to a new regulator when there is a possibility of Gas Leak,
and when the gauge doesn’t go down to zero point,
7）Shut off the Cylinder Valve and loosen the regulator by turning it counter-clock wise when you are not working with the gas for a while.
8）It is MUST to use oil-prohibited regulator for Oxygen, but it is better to have fuel gas regulator oil prohibited too.

Don’t use Oil

At gas inlet and outlet



Keep dust Free

Gas（Oxy-fuel) Cutting / Gas Welding
- Combustion and Explosion

Combustion is an extreme chemical reaction of materials with heat, and usually has bright light.
But, in general, it is about combination of flammable material and oxygen that creates heat and bright light.

Combustion of gases are called Flame.

An Explosion is a rapid increase in volume and release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases. An explosion creates a shock wave. If the shock wave is a supersonic detonation, then the source of the blast is called a “High Explosive". Subsonic shock waves are created by Low Explosives through the slower burning process known as Deflagration.

EXPLOSION MOVIE

Gas（Oxy-fuel) Cutting / Gas Welding
- Gas Welding

Gas Welding
Gas welding is a wide variety of welding method that use mix gas of Combustible Gas and Oxygen or Air, and use the high temperature flame to melt and joint metals.

Gas welding is effective for material that is inferior on thermal conductivity or shape, because it is easy to adjust the temperature and have wide heating area.

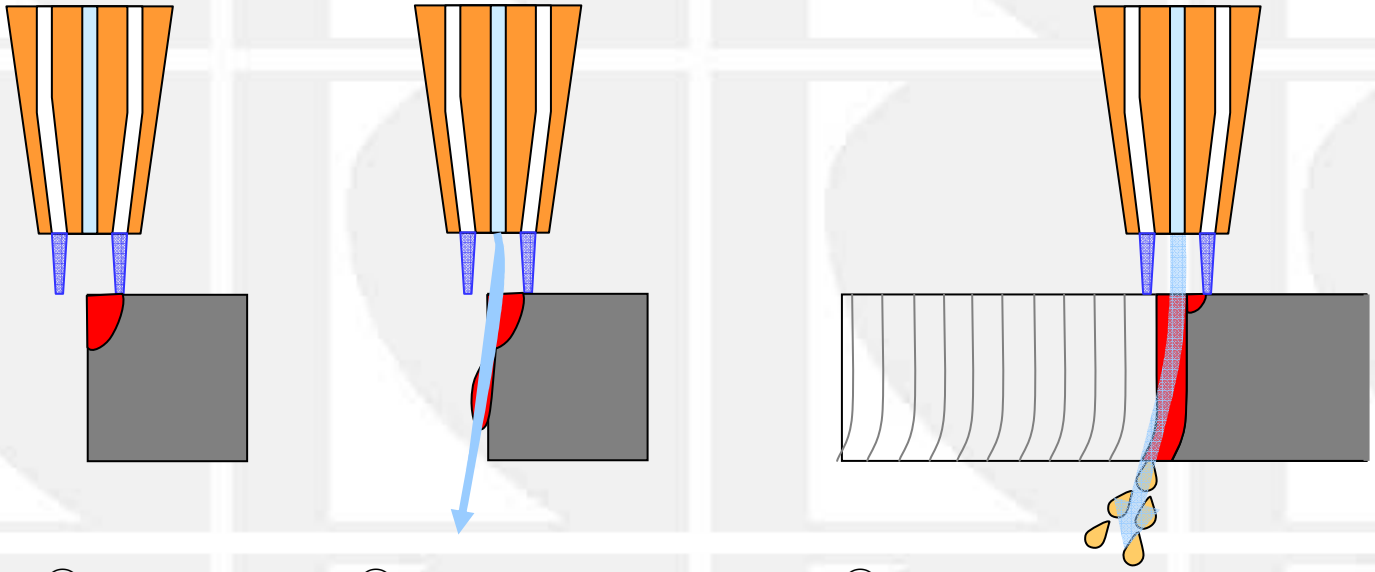
On the other hand, gas welding has possibility of thermal damage to the material because of its long heating time.

Movie 1

Movie 2

Gas（Oxy-fuel) Cutting / Gas Welding
- Principle of Oxy Fuel Cutting

Heat the plate by using Pre-heat flame up to flammable temperature, and blow high purity oxygen to that point to create combustion / melt of the plate.



① Heat

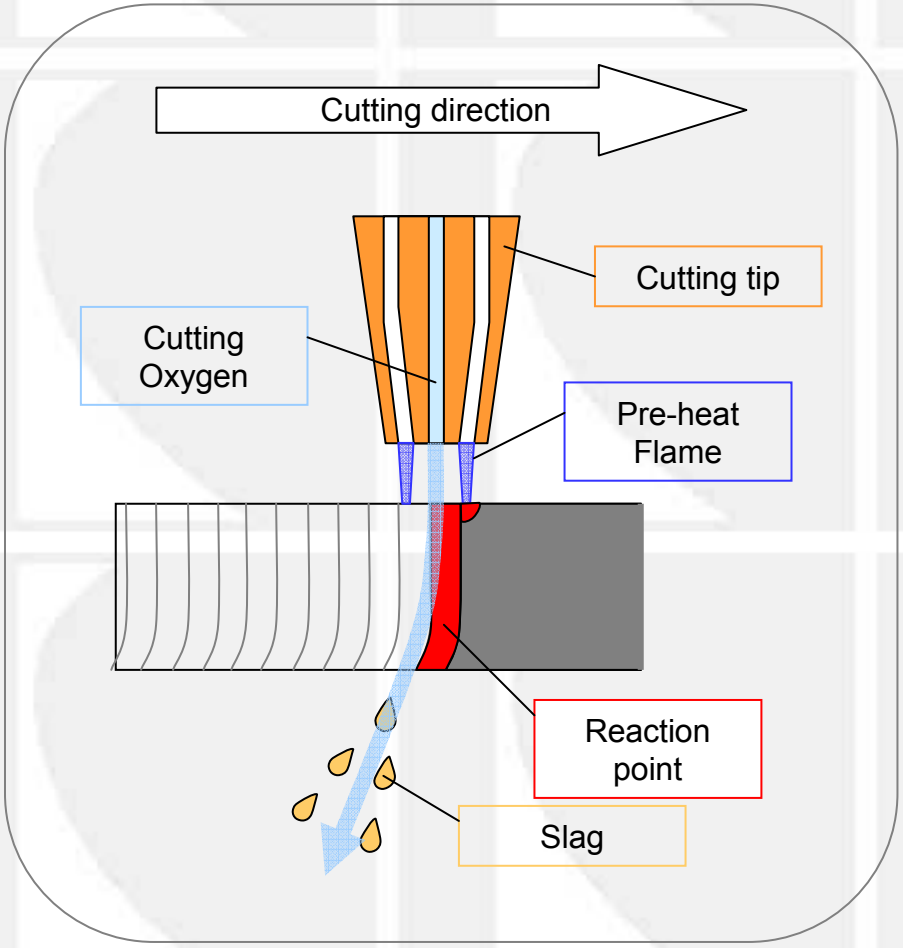
② Blasting Oxygen and melting process

③ Continuous process of Removing slag with / and combustion

Generally, Oxy Fuel cutting can be done with Iron, Low alloy Iron, and Titanium alloy.

Gas（Oxy-fuel) Cutting / Gas Welding
- Principle of Oxy Fuel Cutting

Oxy fuel cutting: Cutting method that melts and remove Iron by the oxidation reaction heat of the Iron itself.

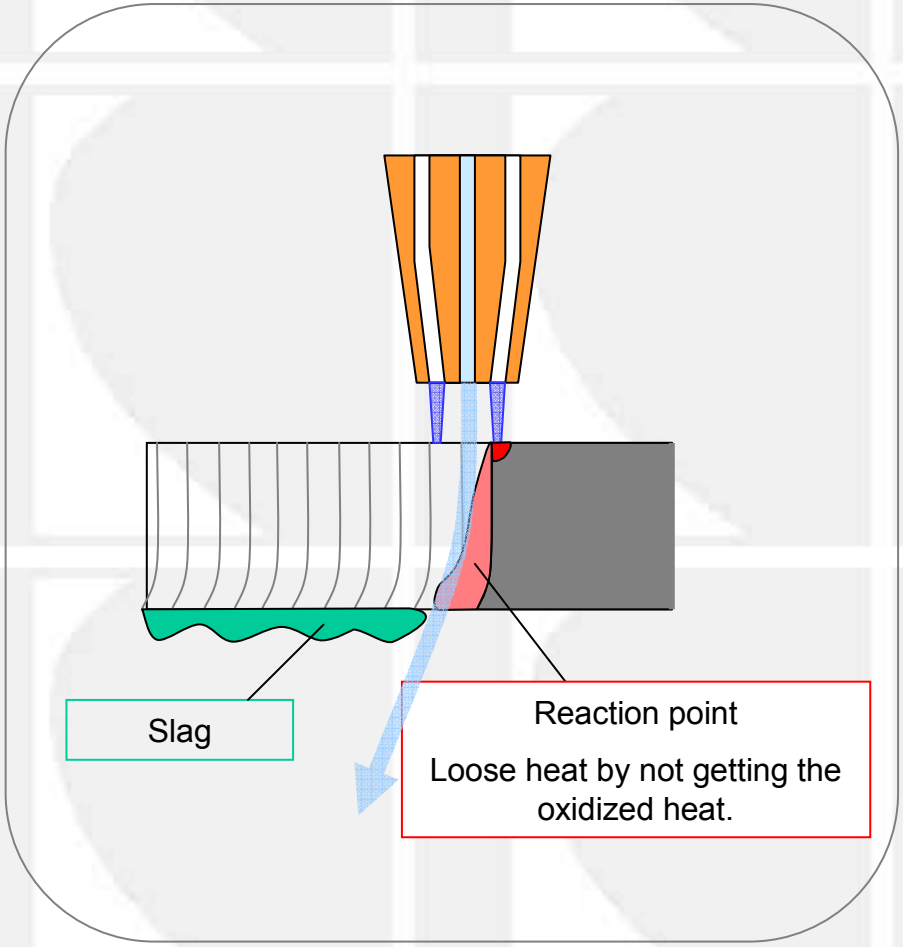


1. **Heat the Iron by Pre-heat Flame.**
2. **When the Iron exceeds the combustible temperature, it starts to combust by the Cutting oxygen, and Reaction point is created by the Oxygen flow.**
3. **Iron at reaction point melts by combustion.**
4. **Molten iron is blasted by the oxygen flow, and un-oxidized iron continuously creates chemical reaction.**

What will be the condition to keep the process above happening?

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

1） Combustible temperature is lower than melting temperature.



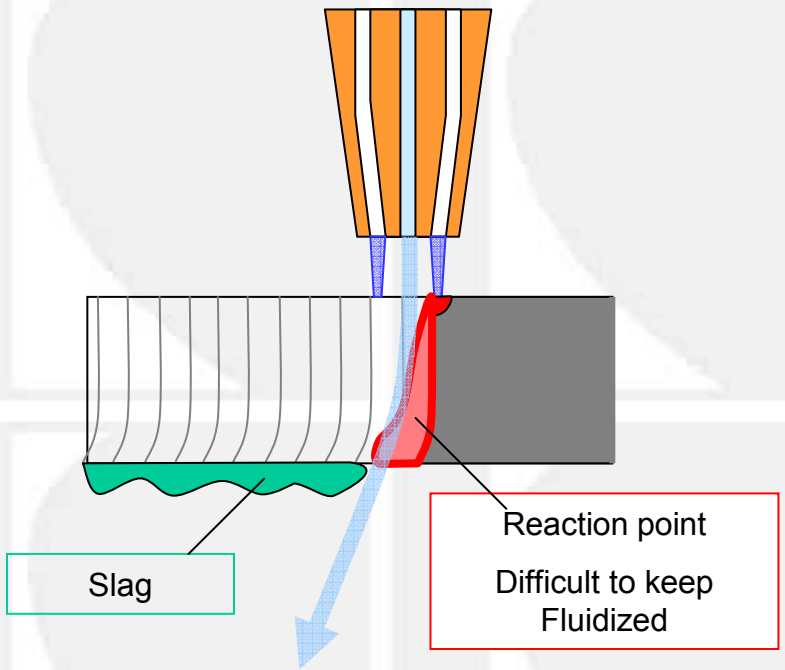
~When not under this condition~

1. **Fluidizing by Pre-Heat before iron combustion starts.**
2. **Loose heat gradually after leaving Pre-Heat, since there is no energy from combustion.**
3. **Stops fluidizing enough and can not remove the iron.**
4. **There is a possibility that it doesn't melt through to the bottom of the iron.**

Thin thickness plate

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

2） Melting temperature of Oxidized material is lower than the melting temperature of the Material to be cut.



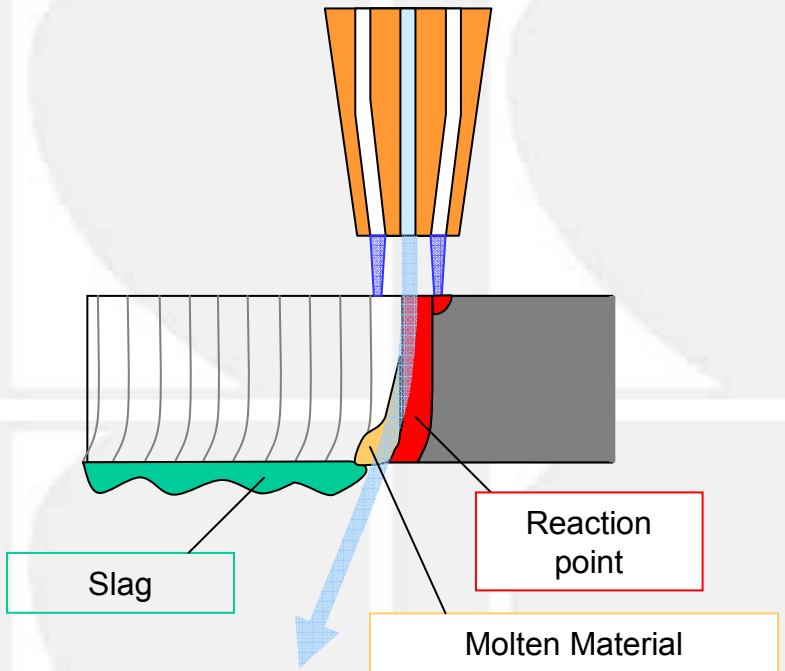
~When not under this condition~

1. **Material melts before oxidized material become fluidized.**
2. **Oxidization stops, can not remove the oxidized meterial, and not enough increase of heat.（not enough liquidity）**
3. **Not enough liquidity.**
4. **Defect of cut by lots of slags at the bottom of the iron.**

ZRP Coated Plate

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

3） Good liquidity of the oxidized material, and easy to remove from the material.



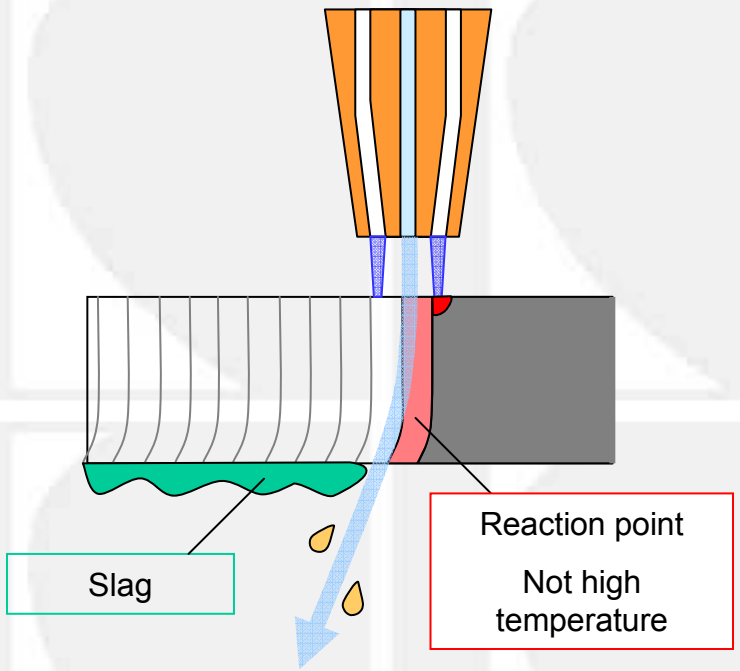
~When not under this condition~

1. **Can not reach to the temperature that makes enough liquidity when combusting the material.**
2. **Slag don't come off enough, and stick to the material.**
3. **There is a possibility that it doesn't melt through to the bottom of the iron.**

SiO2 Silicon

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

4） There are little non-flammable and fluid-obstructing materials in the iron.



~When not under this condition~

1. **Combustion effectiveness is low and not enough energy, even when blowing oxygen to the pre-heated iron.**
2. **Removal is tough because of bad liquidity.**
3. **Slag don't come off and sticks to the material.**
4. **There is a possibility that it doesn't melt through to the bottom of the iron.**

Stainless Steel

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

There are exceptions

表１－５　各種金属の切断性比較[2)]

元素	融点(℃)	酸化物	融点(℃)	単体金属の切断性
Fe(鉄)	1535	FeO	1380	良
		Fe_3O_4	1565	
		Fe_2O_3	1539	
C(炭素)	>3550	CO	−205	否
		CO_2	−57	
Si(ケイ素)	1410	SiO_2	1710	否
Mn(マンガン)	1260	MnO	1785	良
Cr(クロム)	2575*1	Cr_2O_3	2275	不良(高温に予熱する必要あり)
Ni(ニッケル)	1455	NiO	1950	不良
Mo(モリブデン)	2620	MoO_3	795	非常に不良(高温に予熱する必要あり)
W(タングステン)	3370	WO_3	1470	不良
Al(アルミニウム)	660	Al_2O_3	2048	否
Cu(銅)	1082	CuO	1021	否
		Cu_2O	1230	否

Thick Plate Cutting

Manganese is able to cut even with higher melting point temperature of oxidized material compare to the original material.

Generally, Oxy Fuel cutting can be done with Iron, Low alloy Iron, and Titanium alloy.

Gas（Oxy-fuel) Cutting / Gas Welding
- Oxidization of Iron

Chemical reaction of Iron and oxygen

$$Fe + 1/2O_2 = FeO + 64kcal$$
$$2Fe + 3/2O_2 = Fe_2O_3 + 190kcal$$
$$3Fe + 2O_2 = Fe_3O_4 + 266kcal$$

Iron　Oxygen　Oxidized Iron　Heat of combustion

Oxidized Heat of Combustion of Iron

発熱量 / 酸化物	1ｇあたり kcal	1cm³あたり kcal
FeO	1.14	9.00
Fe_2O_3	1.57	12.40
Fe_3O_4	1.69	13.35

Heat of Combustion is about the calorie when certain unit of fuel completely combusted.

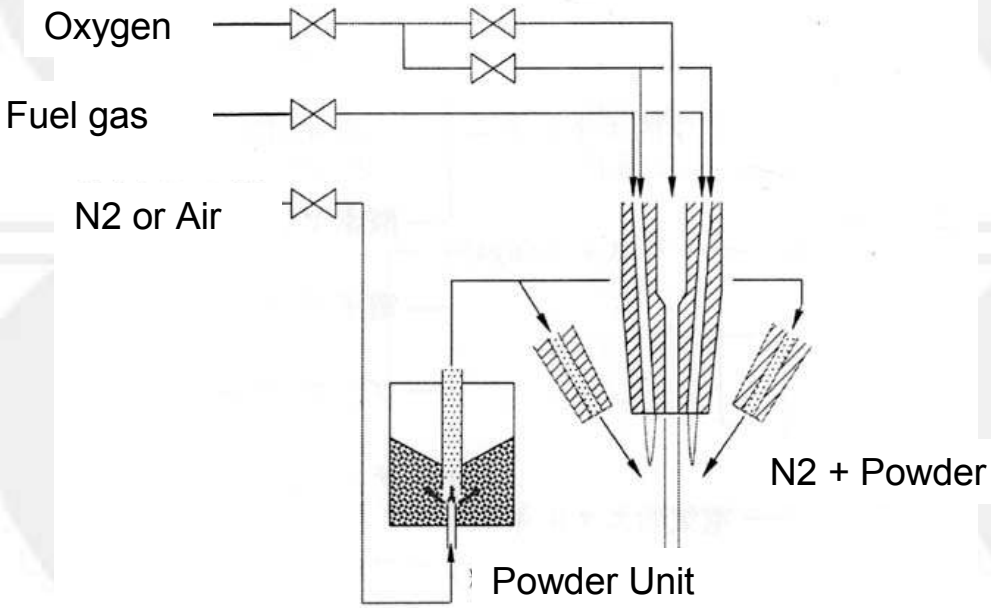
It can melt triple or more iron when iron becomes oxidized iron.

Gas（Oxy-fuel) Cutting / Gas Welding
- Feature of Oxy Fuel Cutting and Performance

Powder Cutting or Oxygen Lance Cutting are used as Oxy Fuel Cutting application when cutting special steel with additional element.

Powder Cutting are used for Stainless Steel or Cast Iron.

Oxygen Lance is used for Large Thick Steel.



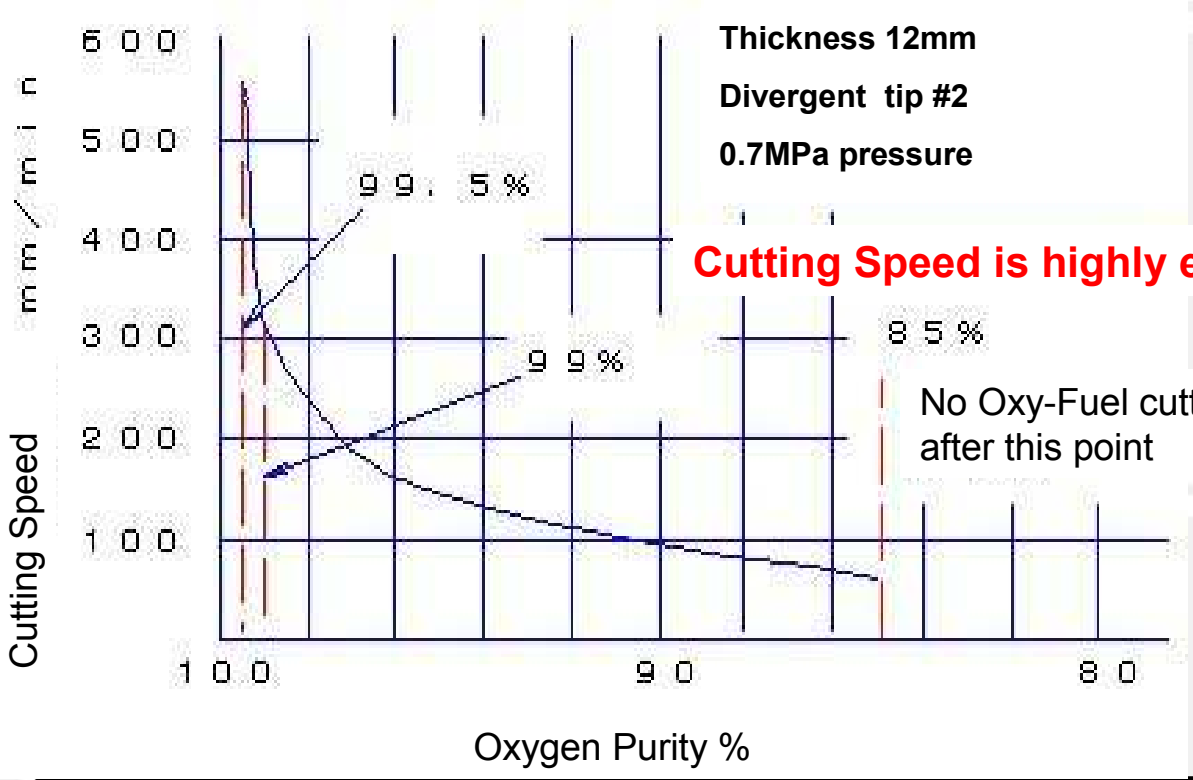
Powder Cutting Structure

Power cutting surface

Gas（Oxy-fuel) Cutting / Gas Welding
- Cutting Oxygen

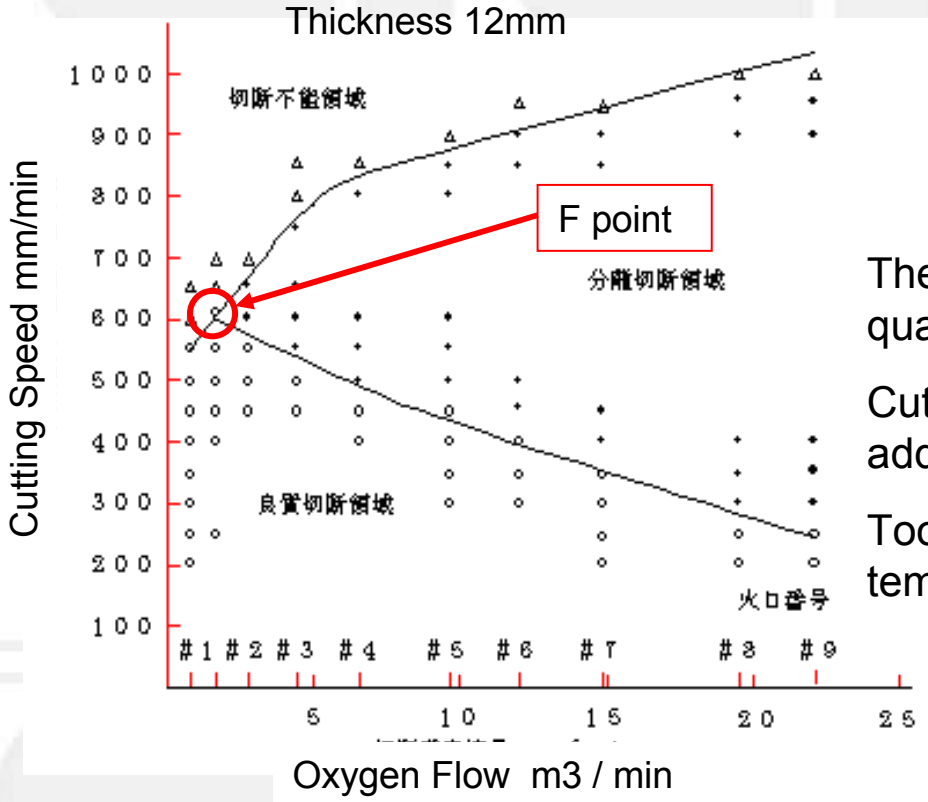
Continuous Oxidization Reaction and Removal of Molten Oxidized Material

Oxy-Fuel cutting is affected by Oxygen purity, Iron purity, and alloy element.



Gas Purity is regulated to 99.5% or more by JIS K 1101

Gas（Oxy-fuel) Cutting / Gas Welding - Cutting Oxygen



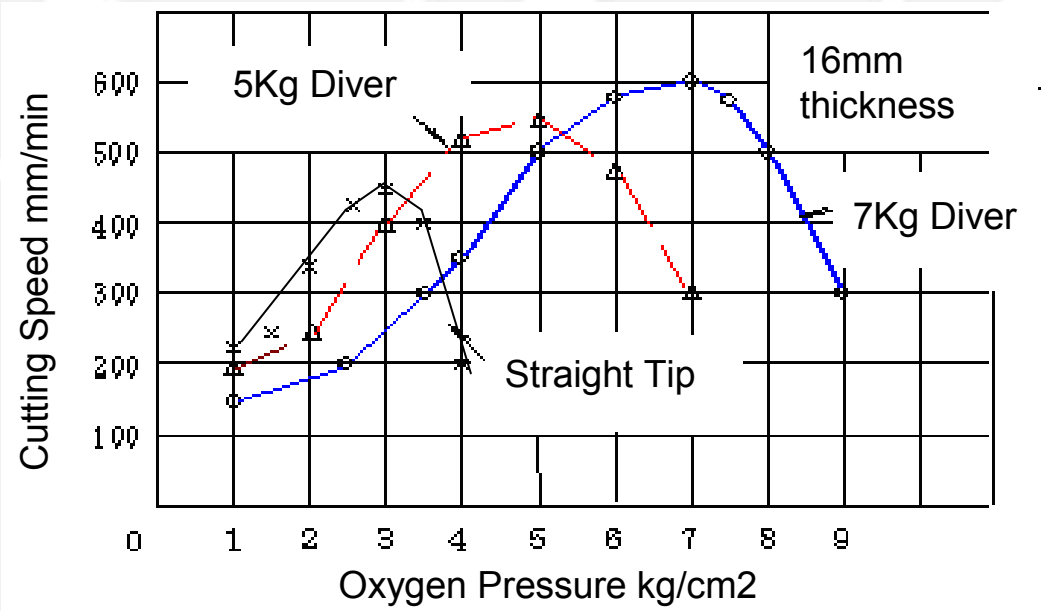
There is maximum cutting speed for high quality cutting range.

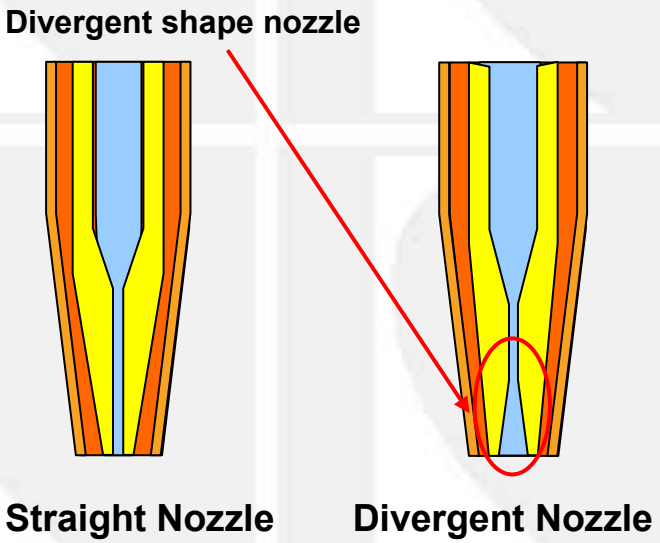
Cutting speed just doesn't increase by adding Oxygen gas amount.

Too much Oxygen flow cools the temperature of material.

Appropriate cutting speed and effective cutting with good quality can be done by selecting cutting tip that is for the cutting thickness.

Gas（Oxy-fuel) Cutting / Gas Welding - Cutting Oxygen



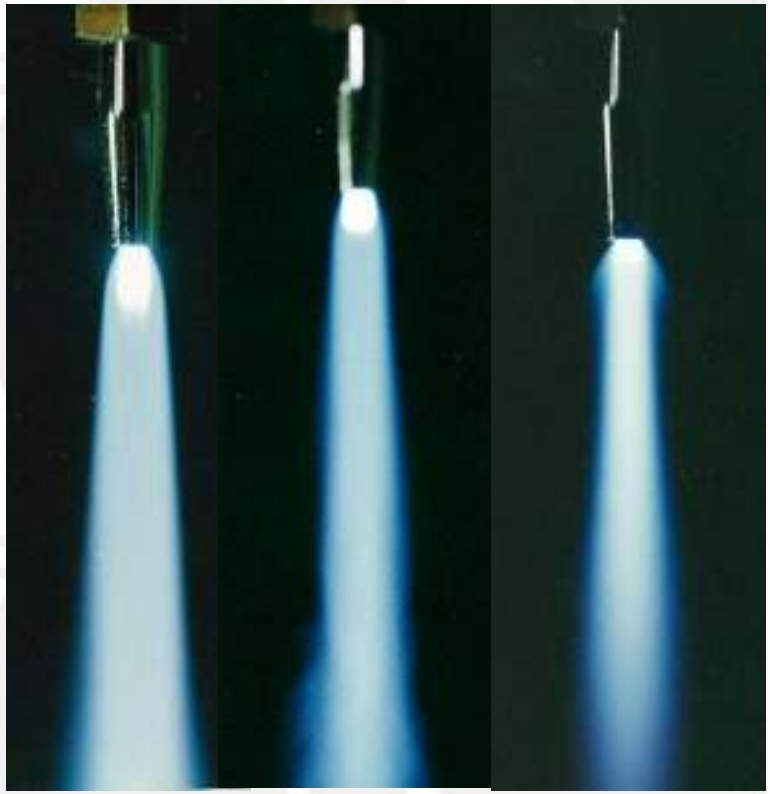


Divergent Tip can have wider range of Oxygen pressure and has faster cutting speed.

Appropriate condition can be set by selecting the cutting oxygen pressure that is for the cutting tip.

Gas（Oxy-fuel) Cutting / Gas Welding - Pre Heat Flame

Heat up to Combustion Temperature, Support Cutting, and Activate the cut surface



Carbonized Flame | Neutral Flame | Oxidized Flame

Appropriate heat efficiency can be achieved by using Neutral Flame.

Prior Flame has about 6mm length when figuring neutral flame.

Pre Heat Flame gets stronger when it gets closer to Oxidized Flame.

Gas（Oxy-fuel) Cutting / Gas Welding - Pre Heat Flame

✓Activates the surface of metal

✓Keeps the momentum of the cutting oxygen flow

✓Keeps the purity of the cutting oxygen (Important)

Stable oxidization and stable cutting can be done with Pre Heat Flame.

Gas（Oxy-fuel) Cutting / Gas Welding - Pre Heat Flame

Generally, Cutting speed shows improvement when adding Pre Heat Fuel Gas.

Principle of Pre heat flame

When Pre heat flame is strong:

Cutting speed improves by having stable oxidizing reaction.

Shoulder edge gets rounded when too strong.

When Pre heat flame is weak:

Oxidizing reaction becomes unstable and could loose flame.

Cutting parameter chart are made by the minimum amount of pre heat fuel gas flow that can get the best cut quality and maximum cutting speed.

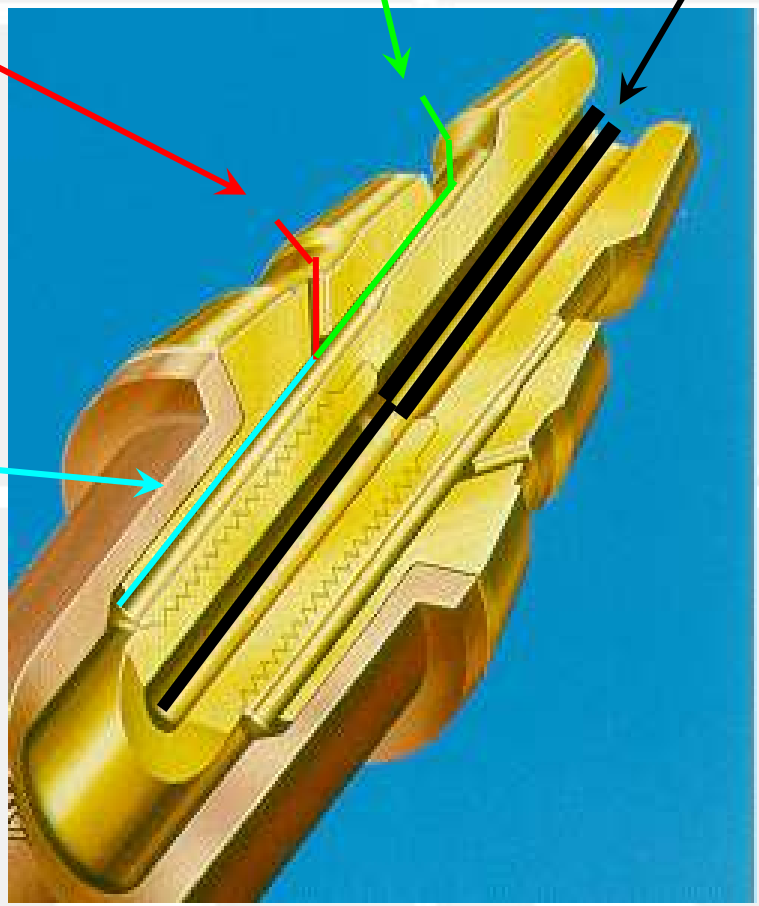
Tip Mixing for a Safer Cutting Torch

FUEL GAS

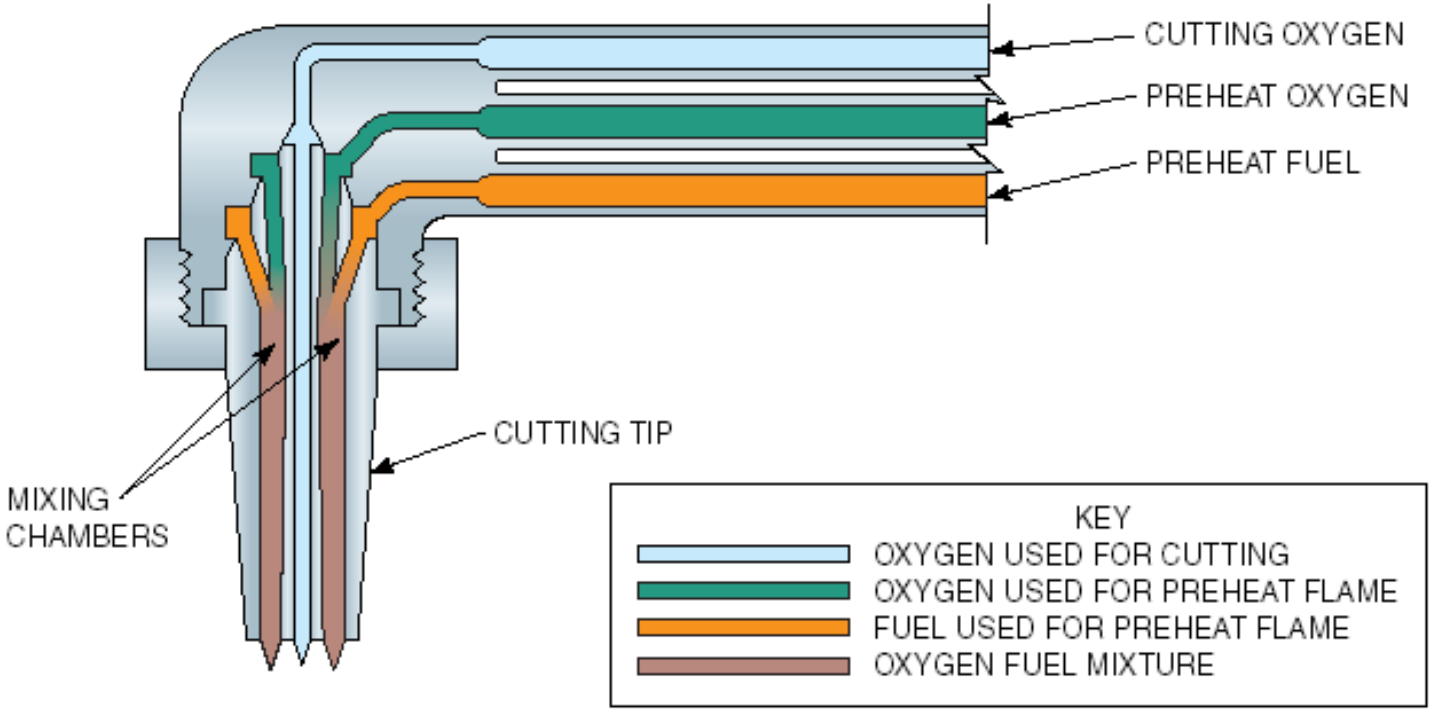
MIXED GAS

CUTTING OXYGEN

PREHEAT OXYGEN

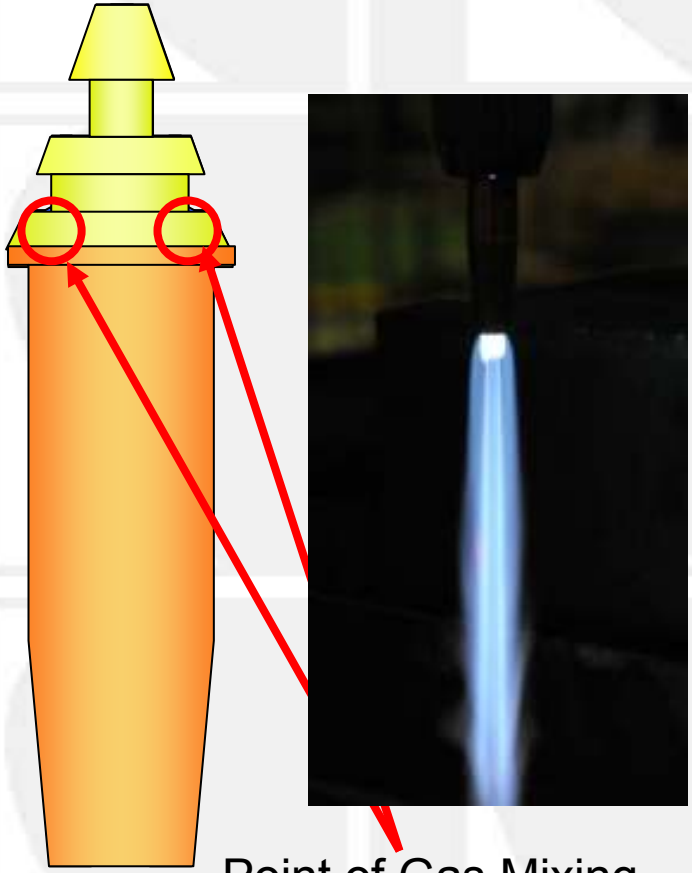


Koike Style Torch



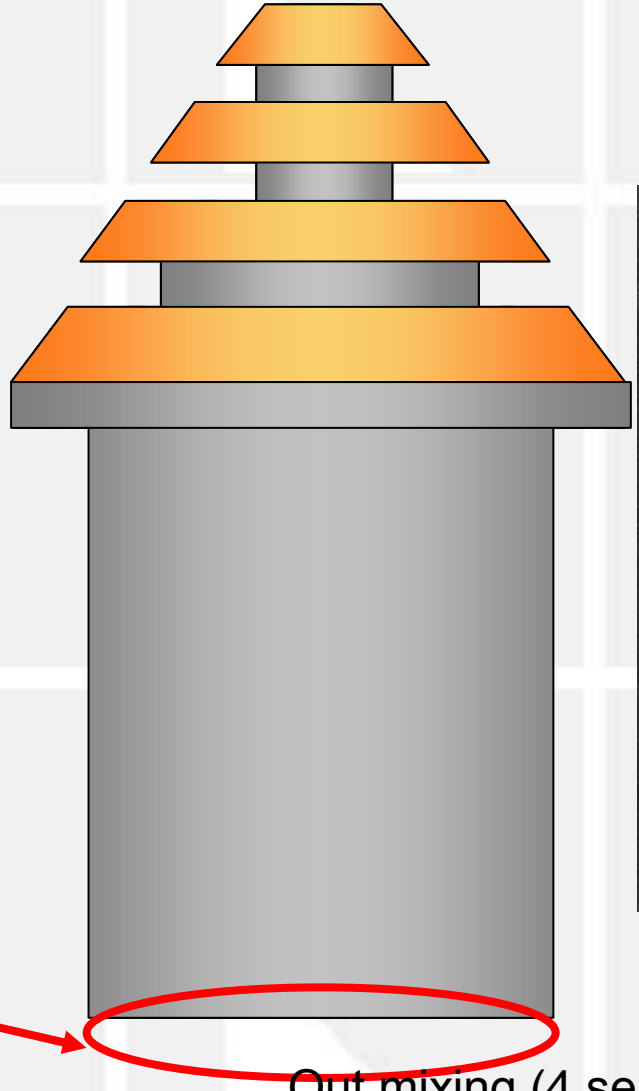
Oxy Fuel Cutting Performance and Safety

Cutting Tips: Tip Mixing and Out Mixing



Point of Gas Mixing

Tip mixing (3 seat fitting)



Out mixing (4 seat fitting)

Gas（Oxy-fuel) Cutting / Gas Welding
- Material to be cut

Element	Effect to Oxy fuel cutting
Carbon	Good cut can be achieved up to 0.25% Carbon. High carbon steel needs pre heat to avoid hardening and crack. Graphite and Cementite (Fe3C) obstruct oxy fuel cutting, but 4% carbon cast iron can be cut by special method.
Manganese	Manganese itself can be cut by oxy fuel cutting. It is difficult to cut 14% Manganese 15% Carbon steel unless using pre heat flame.
Silicon	No effect to oxy fuel cutting up to 4% Silicon. Pre heat and Post heat have to be done carefully to cut with good quality, for carbon and manganese rich Silicon steel.
Chrome	Pure Chrome reacts with oxygen only in very high temperature. It is not difficult to cut 5% Chrome Steel. Special cutting method has to be done with 10% Chrome steel, and it is difficult to achieve good quality cut. Carbonized Flame can achieve better result with this type of steel. It is easy to cut by Power Cutting Method, same as Stainless Steel.

Gas（Oxy-fuel) Cutting / Gas Welding
- Material to be cut

Element	Effect to Oxy fuel cutting
Nickel	4% Nickel steel can be cut without issue if carbon is not contained in high ratio. Up to Nickel 9% will have good cut result. Industrial Stainless alloy such as SUS 304, 316 can be cut by Powder Cutting Method.
Molybdenum	Similar to Chrome. It is difficult to cut Pure Molybdenum. It is not difficult to cut Chrome – Molybdenum Steel for Aerospace industry. High Molybdenum / Tungsten steel needs special method of cut.
Tungsten	Pure Tungsten ca nbe cut with enough pre heat. 12～14% Tungsten alloy can be cut easily, but it becomes difficult to cut when it exceeds 20%.
Copper	2% Copper doesn't have effect. There is no problem unless it has high Aluminum such as 10%.
Phosphorus	No effect when it is in range of allowance in steel.
Sulfur	No effect in amount that exists in steel, but it reduces cutting speed when there is a lot of sulfur. Have to be careful of Sulfurous acid fume.
Vanadium	It rather makes cutting easier with the amount that exists in steel.

Gas（Oxy-fuel) Cutting / Gas Welding - Quality Standard 1

	Item	Item detail	Standard			Other standard
			WES and ISO	Summary of Standard	Note	
Quality	Quality of cutting surface	Roughness	WES2801 ISO9013	1st grade：50S 2nd grade：100S 3rd grade：200S (10 point height irregularity) Quality Ⅰ：3mm 70μm 300mm 430μm Quality II：3mm 100μm 300mm 650μm Compare with rolled material sample, Thickness 50mm Material that is able to Oxy-fuel cut.	Material that is able to Oxy-fuel cut.	JIS B 0417 Oxy-fuel cutting regular allowance
		Flatness	WES2801 ISO9013	1st grade：(1/100) tmm 2nd grade：(2/10) tmm Right-angled allowance and Angle allowance	Compare to sample	
		Edge angle	ISO9013	Right-angle allowance and Angle allowance Quality I: 3mm 0.4mm 300mm 3.4mm Quality II: 3mm 1.0mm 300mm 5.5mm		JIS B 0417
		Melt at Top	WES2801 ISO9013	1st grade: No melting but a little roundness at shoulder. There is no grading.	Compare to sample	
		Slag	WES2801	1st grade: Grainy slag, but no damage to the steel and come off naturally.	Compare to sample	
		Bevel angle	WES2801	1st grade: Land ≦±1.5° Bevel surface ≦±3°		

Gas（Oxy-fuel) Cutting / Gas Welding - Quality Standard 2

	Item	Item	Item detail	Standard		
				Summary of Standard	Note	
	Accuracy	Straight-ness	WES2801 ISO9013	Put a standard / guide line and scale the maximum difference from the actual cut line. 1st grade: 0.4mm Graded by thickness division of parallel straight line cutting.	Nominal Size up to 10,000	JIS B 0417
		Square-ness		Put a standard / guide line on long edge, and put another lines for short edges and scale the distance.		JIS B 0417
		Cut length and width	ISO9013	Graded by thickness division, and standards based on Material size division		JIS B 0417

Gas（Oxy-fuel) Cutting / Gas Welding - Defect and measures-1

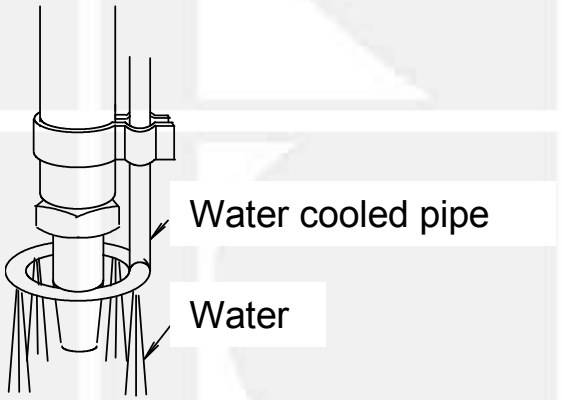
Molten top edge

Cause
① Too strong Pre Heat Flame
② High temperature of cut material
③ Cutting tip is positioned too high

Measures
① There are two ways to make “Too strong pre heat flame”. One is by too much gas flow and other is by Oxidized flame.
Need to lower gas flow or make a neutral flame.

② When material temperature is high, reduce Fuel Gas pressure 20% - 40%, and reduce Pre heat oxygen to make a semi-Carbonized Flame. It will also work by spraying water to the material.

③ Adjust cutting tip height from the material.



Gas（Oxy-fuel) Cutting / Gas Welding
- Defect and measures-2

Defect on Flatness （scooped)

Cause

① Cutting Oxygen pressure not set as tip parameter.
② Spatter / Slag in cutting tip orifice.
③ Cutting speed is too high
④ Tip height is too high
⑤ Low purity of cutting oxygen.

Measures

① Check if the cutting oxygen pressure is set appropriately.
② Clean the cutting tip orifice.
③ Check if the cutting speed is set correctly by tip number and material thickness.
④ Change cutting tip
⑤ Check the material if it is a special steel.
⑥ Check the purity of cutting oxygen.

Gas（Oxy-fuel) Cutting / Gas Welding - Defect and measures-3

Rough cut surface

Cause

① Cutting Oxygen pressure not set as tip parameter.
② Spatter / Slag in cutting tip orifice.
③ Cutting speed is too high
④ Cutting tip number is not appropriate for the thickness.
⑤ Cutting height and cutting speed are not correct.
⑥ Low purity of cutting oxygen.
⑦ Cutting special steel

Measures

① Check if the cutting oxygen pressure is set appropriately.
② Clean the cutting tip orifice.
③ Check if the cutting speed is set correctly by tip number and material thickness.
④ Change cutting tip.
⑤ Check material type if it is special steel.
⑥ Check the purity of cutting oxygen.

Gas（Oxy-fuel) Cutting / Gas Welding
- Defect and measures-3

Slag at bottom

Cause

① Cutting Oxygen pressure not set as tip parameter.
② Spatter / Slag in cutting tip orifice.
③ Cutting speed is too high
④ Cutting tip number is not appropriate for the thickness.
⑤ Cutting height and cutting speed are not correct.
⑥ Low purity of cutting oxygen.
⑦ Cutting special steel

Measures

① Check if the cutting oxygen pressure is set appropriately.
② Clean the cutting tip orifice.
③ Check if the cutting speed is set correctly by tip number and material thickness.
④ Change cutting tip.
⑤ Check material type if it is special steel.
⑥ Check the purity of cutting oxygen.

Gas（Oxy-fuel) Cutting / Gas Welding
- Defect and measures-4

Notches

Cause

① Too weak pre heat flame.
② Bad material surface condition.
③ Cutting special steel.
④ Vibration of cutting equipment, or the material (Most of the case in actual application)
⑤ Water entered to the cut kerf while cooling.

Measures

① Weak pre heat flame makes the cut result easier to be reflected by the material surface condition. Need stronger pre heat flame.
② Need 1.5 times pressure for pre heat flame when cutting Zinc Coated material.
③ When black scale is not tight to the material, need to etch the material surface to remove the scale before cut.
④ When there is prior zinc powder marking, remove the marking line on the cutting line.
⑤ Clamp the material when there is vibration.

Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Combustion speed and stability of flame

Combustible speed of fuel gas is decided by gas type and mixing ratio with oxygen.

Combustible speed is depending on mixing ration with oxygen, and there is zero combustible speed as single unit. This means it can not combust by itself. So, there is no way to create Flash-back, and there is always oxygen mixed with the combustible gas when Flash-back happens.

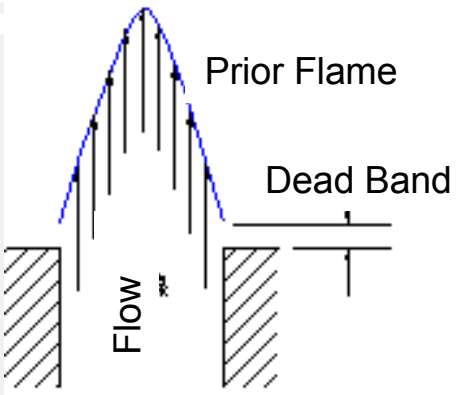
Combustible speed of Propane and Oxygen mixed by theory mixing ratio is 3meter/second.

Acetylene resolves with heat and it can make explode depending on condition.

Gap between tip edge and Prior Flame is called “Dead Band”.

“Dead Band” expands when Fuel Gas Flow is too high, and causes Blow Out.

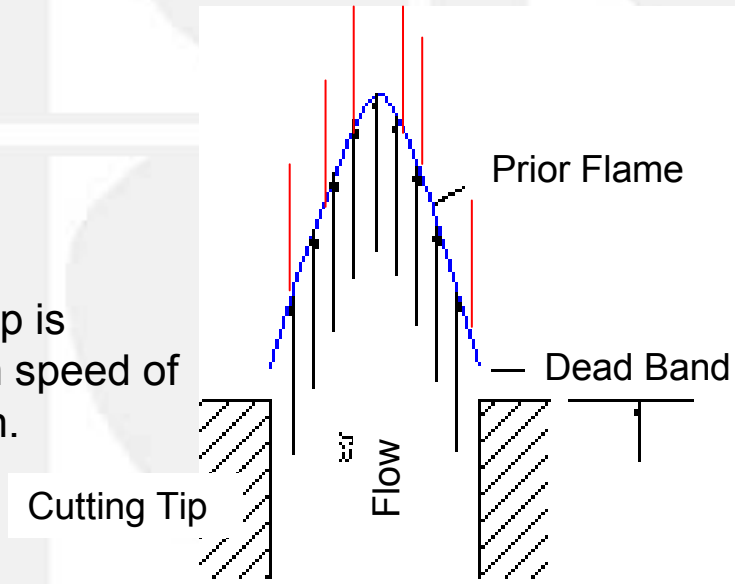
Prior Flame can come back inside the tip when Fuel Gas Flow is too low, and this is called “Flash-back.”



Gas（Oxy-fuel) Cutting / Gas Welding - Safety – , Back Fire / Flash Back

Stable flame at cutting tip

Gas flow speed out from the tip is balancing with the combustion speed of mixed gas of fuel gas / oxygen.



Flame can come back inside the tip when gas flow speed get under combustion speed.

This phenomenon is called Back Fire.

Gas（Oxy-fuel) Cutting / Gas Welding - Safety – Back Fire / Flash Back

Sound (“PACHIN”) Back Fire

Flame comes in the tip a little and extinguished with a sound. This happens at tip extinction, or when you touches the plate with tip while cutting. This is not included in Flash Back in Oxy-fuel cutting industry.

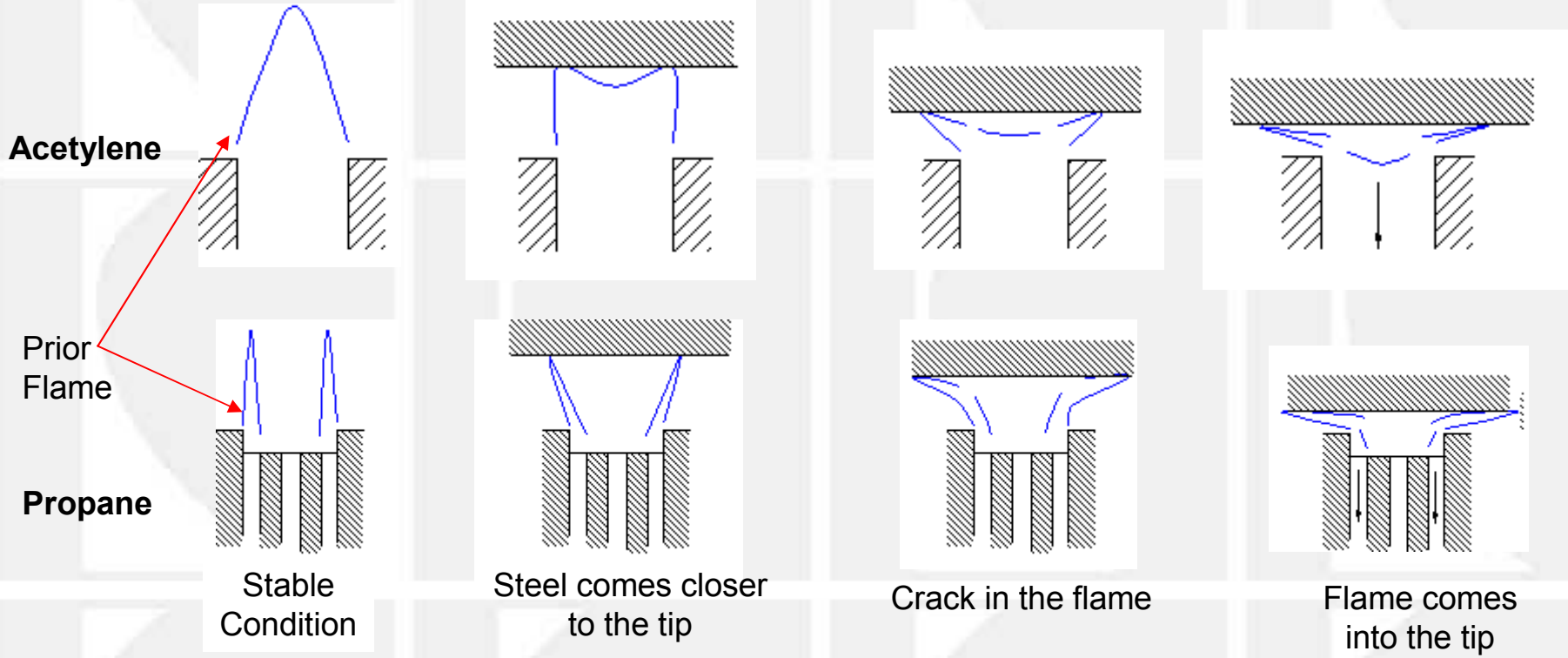
Continuous Flash Back

This is about a situation when flame doesn’t extinguish after it entered into the gas apparatus. This can create damage to the apparatus, or create Flash Back.

Flash Back

Create explosion when flame comes back into supply side (such as gas cylin

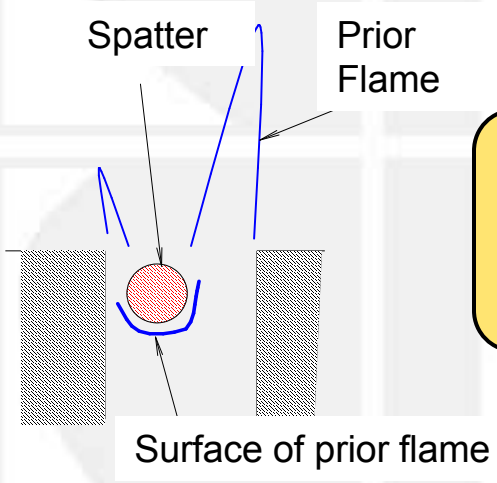
Gas（Oxy-fuel) Cutting / Gas Welding - Safety – Cause of Flash Back



Back Fire happens when tip-end is closed while there is a flame.
Propane Tip has pocket and it is much dangerous since the flame can stay in the pocket.

Back Fire happens every time when Acetylene is used with Propane tip.

Gas（Oxy-fuel) Cutting / Gas Welding - Safety – Cause of Flash Back

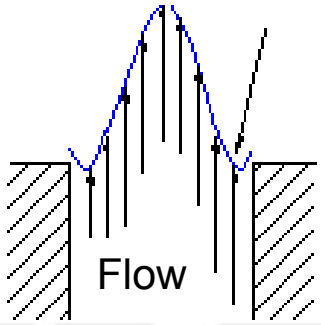


It has high possibility of creating Flash Back when there is Slag inside the tip and clogging the tip.

Flash Back happens when there is no Dead Band by increasing temperature of the cutting tip.

This is considered that Gas Mixing Ratio looses its balance when cutting tip temperature increases.

No Dead Band and Flame comes into the tip



Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Cause of Flash Back

Usually, actual gas mixing ratio is lower than theory gas mixing ratio, when creating neutral flame.

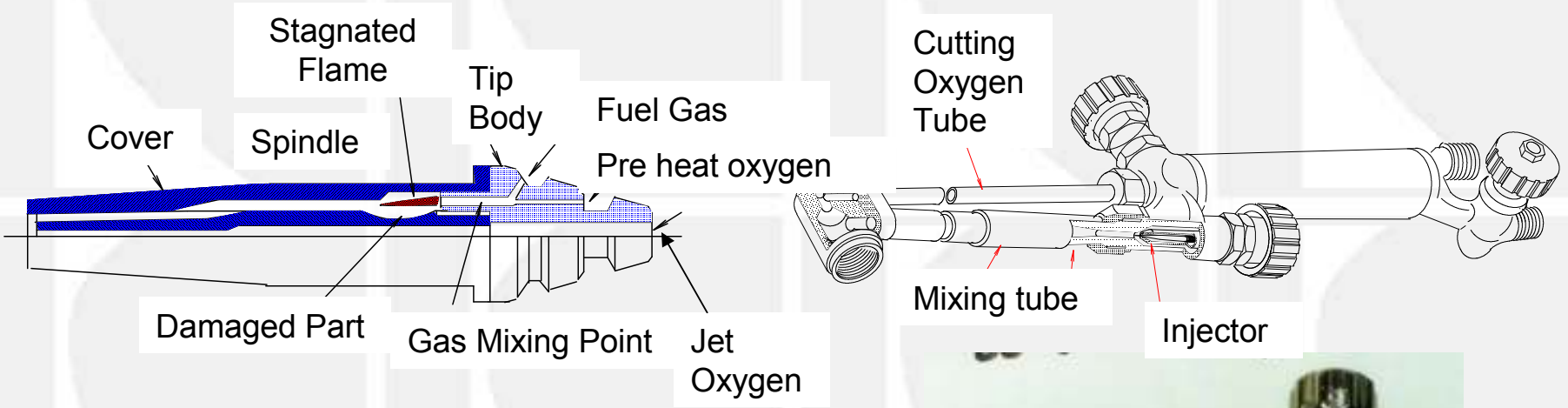
Trend is that the combustion speed increases from gas mixing ratio of neutral flame to theory gas mixing ratio.

Fuel gas	Mixing Ration of Neutral Flame	Theory Gas Mixing Ratio
Acetylene	1．1	2．5
Propane	3．8	5．0
Ethylene	1．8	3．0
Natural Gas	1．7	2．0

Flash Back could happen with increased combustion speed when the stable neutral flame changes to a flame of theory gas mixing ratio.

Gas Flow tend to be lower than needed when inspect the accident cases of Flash Back.

Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Continuous Back Fire and measures



Damaged Injector

Cases of damage to the tip or torch injector
(1) Closed cutting tip orifice　(2) Spatter or Slag to the tip

If you can not see the flame coming out from the tip, you can avoid accident by stopping the gas supply immediately.

When stopping the gas supply, first stop the Oxygen, and then stop the Fuel Gas.

Hazards of Torch Mixing

Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Cause of Flash Back and measures

Mixture with Oxygen is always happening when there is Fuel Gas hose blast and when there is heat damage inside the Regulator.

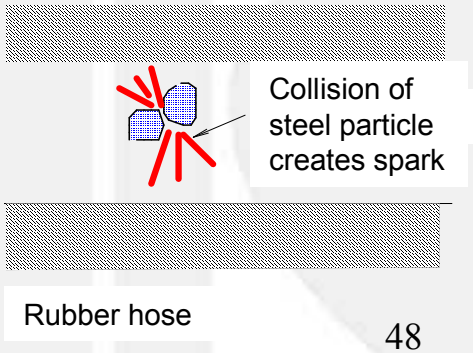
① There was air inside the hose.
② Backflow of Oxygen to the Fuel Gas side.
③ Gas supply stopped at the Fuel Gas side while flam
④ Defect of gas apparatus.

Back Fire →

In the case of heat damage inside regulator, it can be judged either if the damage was caused by flash back or combustion caused by blasting pressure-gauge.

This can be judged by amount of carbon (grime) adhesion, and carbon (grime) tends to adhere to the flame flowing side.

Oxidization is happening when material is combusting. Everything that can combust is fuel around oxygen.
Steel particle inside the hose can spark and ignite the hose.



Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Cause of Flash Back and measures

Through experiences, 80% and more of all the Flash Back happens at first job in the morning, and first job in the afternoon. This is because of mixture of gases created in the hose / piping by some reason.

To avoid these accidents, the most effective way is to Purge The Gas before starting the job.

As procedures for gas purge,

① Check there is no cause around the cutting machine.

② Check there is no open valve on each torch.

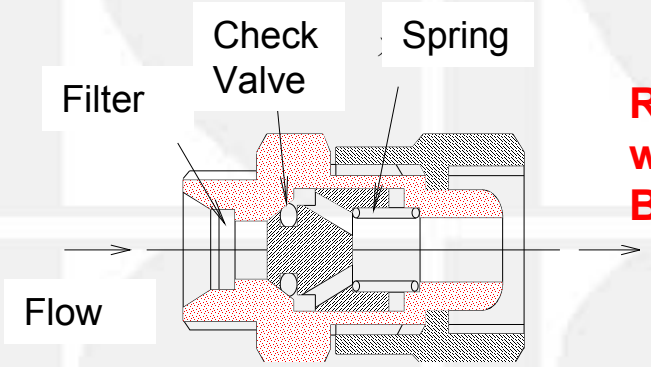
③ Open the valves of oxygen and fuel to a set pressure.

④ Open the valve for pre heat oxygen and release the pre heat oxygen for about 20 seconds. ALWAYS close the torch valve after releasing the oxygen.

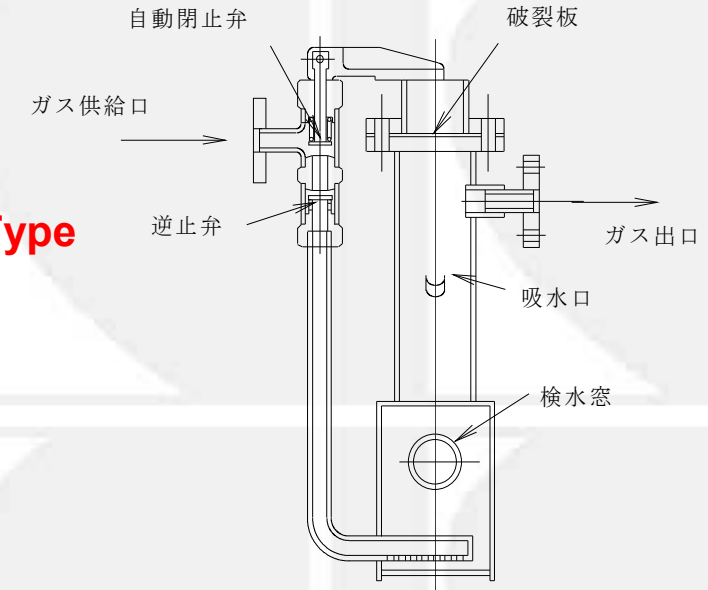
⑤ Open the fuel gas valve and release the gas for about 5 seconds. ALWAYS close the torch valve after releasing the fuel gas.

⑥ Wait about a minute after releasing the fuel gas, and then release the cutting oxygen for about 20 seconds. ALWAYS close the valve after releasing the gas. Start the cutting job after these gas purges.

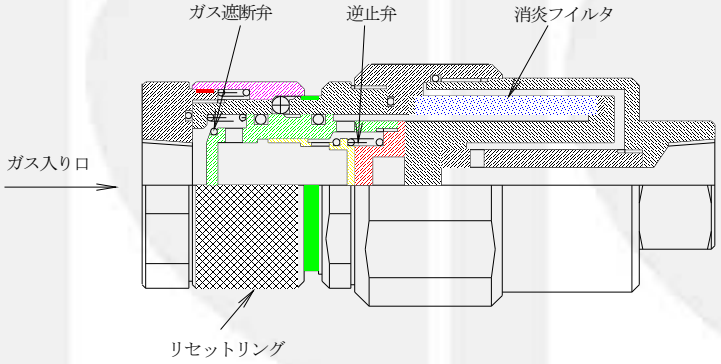
Gas（Oxy-fuel) Cutting / Gas Welding
- Safety – Structure of Safety Equipment



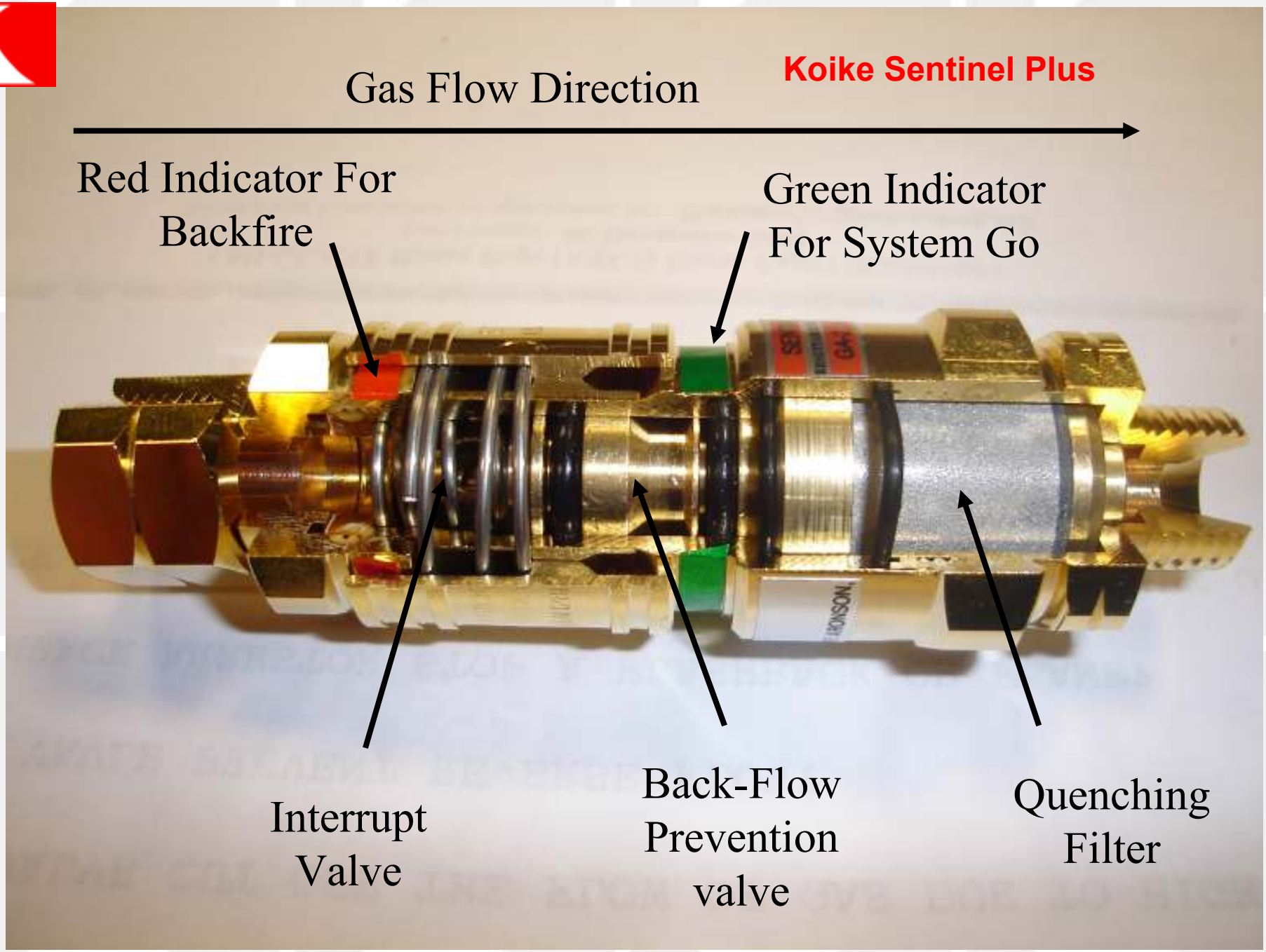
Reverse Flow Check Valve is not to avoid the flame when Back Fire happens. It rather works to prevent the Back Fire.

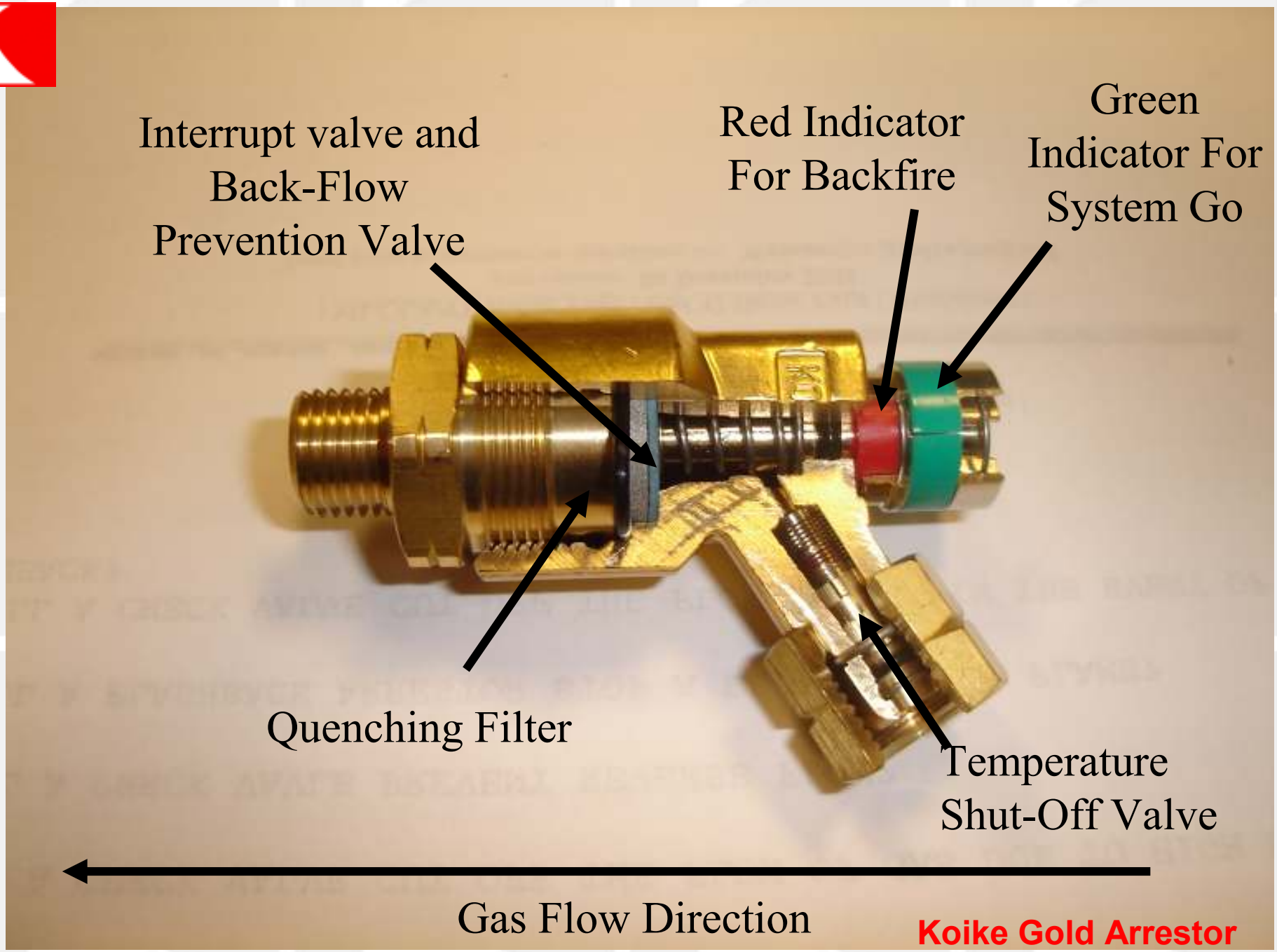


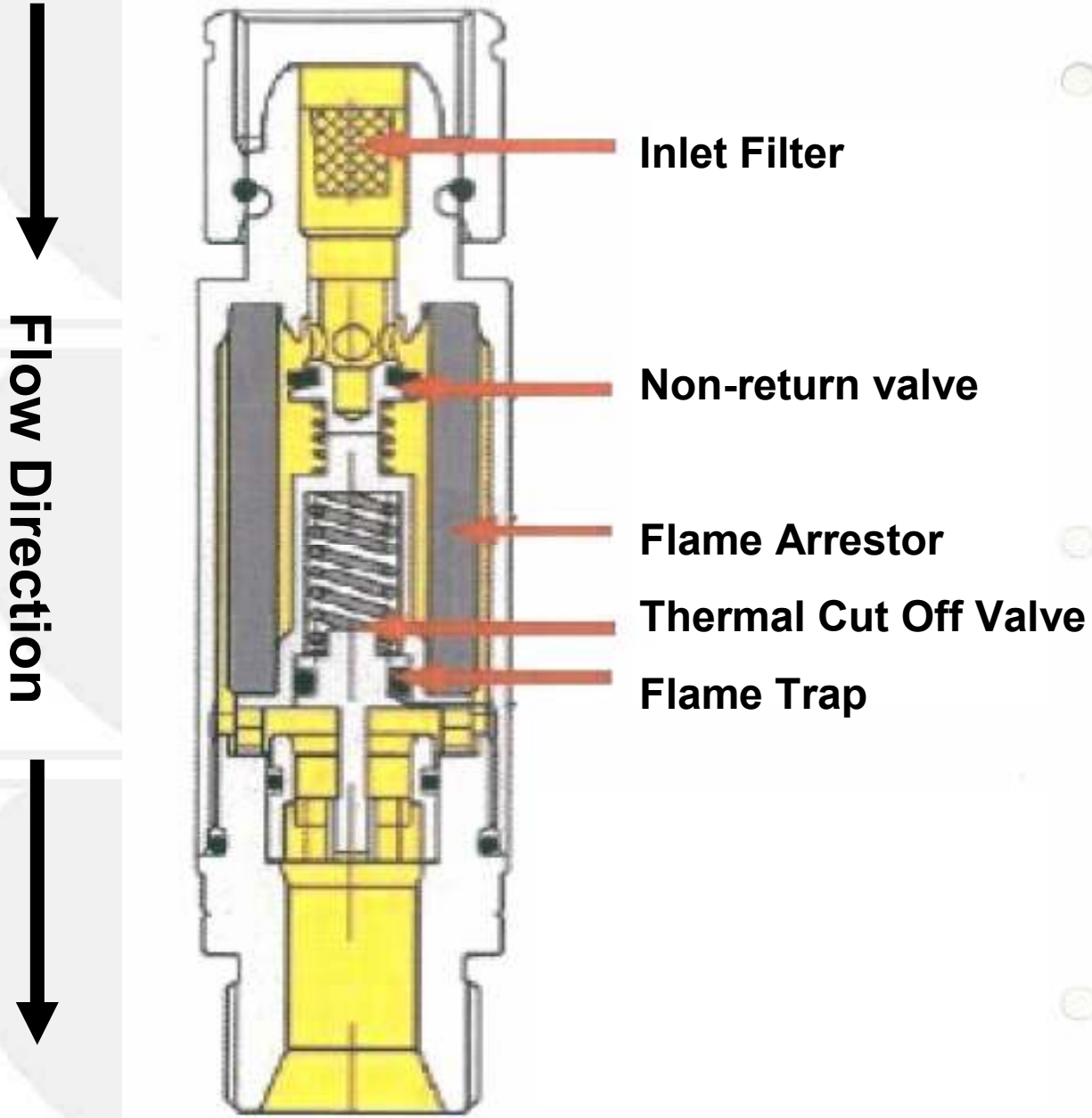
It is necessary to inspect the water of Water Sealed Type Flash Back Arrestor everyday, since it doesn't work without water.



Dry Type Flash Back Arrestor is regulated to be checked by end-user once a year, and to be checked by manufacturer or a certified technician once in three years.

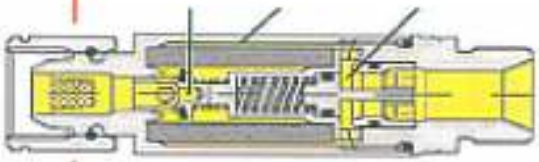

Koike Sentinel Plus
Gas Flow Direction
Red Indicator For Backfire
Green Indicator For System Go
Interrupt Valve
Back-Flow Prevention valve
Quenching Filter


Interrupt valve and
Back-Flow
Prevention Valve
Red Indicator
For Backfire
Green
Indicator For
System Go
Quenching Filter
Temperature
Shut-Off Valve
Gas Flow Direction
Koike Gold Arrestor


Flow Direction
Inlet Filter
Non-return valve
Flame Arrestor
Thermal Cut Off Valve
Flame Trap

How Flashback Arrestors Work

Check valve Flame Barrier Thermal Cut-off



Normal Gas Flow

Normal gas flow in yellow flowing through the flashback arrestor to torch, hose or pipeline.

Built in check valve stops the reverse flow of mixed gases

Reverse Gas Flow

Here the reverse flow of an explosive mixture of gases depicted in blue is stopped by the flashback arrestor's built in check valve. Reverse flow of the gases is often caused by operator error, improper gas pressures, faulty or defective equipment, and/or obstruction at or after the point where gases mix.

Flame barrier quenching flashback flame

Flashback

The next step is the ignition of the mixed gases called a flashback shown here in red. The flashback causes a rapid flame propagation upstream to the equipment and gas supply. Here it is stopped by the flame barrier. Flashback can cause serious personal injury and/or equipment damage.

Thermal shut-off cutting off gas flow to fire

Hose Burn Back

Hose burn back shown here in red is an oxygen enriched fire or fuel decomposition in the hose or pipeline which flows back to the equipment and gas supply. In the illustration the hose burn back is stopped by the thermal cut off.