Franklin County School District

School Closure Packet

Week Two: March 30-April 3

Career & Technical Center

Please find the pages that are for your program.

Name:

____

Career-Tech Teacher:

____

Contemporary Health 4th and 5th Periods
Week of March 30th – April 3rd

Log into your ICEV account and complete the following assignments as you watch the video or Powerpoint:

1) Communication Styles – *CC*
- Communication Styles – Communication Process & Models – Student Notes & Assessment I
- Communication Styles – Listening Process – Student Notes & Assessment II
- Communication Styles – Non-Verbal Communication – Student Notes & Assessment III
- Communication Styles – Professional Communication – Student Notes & Assessment IV
- Communication Styles – Communication & Society – Student Notes & V
- Communication Styles – Vocabulary & Assessment VI
- Communication Process Diagram & Final Assessment

Resource Management 1st, 2nd, and 3rd Periods
Week of March 30th – April 3rd

Log into your ICEV account and complete the following assignments as you watch the video or Powerpoint:

1) Investments Defined – *CC*
- Investments Defined – Vocabulary
- Investments Defined – Worksheet
- Investments Defined – Assessment

2) Financial Literacy: Homeownership – *CC*
- Financial Literacy: Homeownership – Vocabulary and Assessment I
- Financial Literacy: Homeownership – Worksheet and Assessment II
- Renting vs. Owning
- Mortgages
- Steps for Buying a Home
- Cost of a Home
- Financial Literacy: Homeownership Assessment III
- Financial Literacy: Homeownership Assessment IV
- Financial Literacy: Homeownership Assessment V

ANR I
UNIT 4
ESSENTIAL QUESTIONS, REVIEW AND TERMS

1. What benefits does humanity obtain from domesticated animals?
2. What processes are used in the production, processing, and marketing of animals and animal products?
3. How is the agricultural animal industry reacting to the animal rights and welfare issue?
4. What are the functions of the different parts of a cell?
5. How does mitosis allow cells to divide and reproduce?
6. What are the components and functions of the major systems of an animal's body?
7. How is the reproduction process in mammals and birds similar yet different?
8. How does the digestive process differ from one species of animal to another?
9. What are the six essential nutrients, and how are they used for growth and development?
10. What are the most commonly used feedstuffs, for animal rations, and with which species is each associated?
11. How are traits passed from the parent to the offspring?
12. Why does an egg or sperm cell contain only half of the parent's chromosomes?
13. What is the process of selective breeding?

REVIEW

*Domesticated animals continue to provide services to humanity, including meat and dairy products, wool, labor and service, and companionship.
*The production, processing, and marketing of animals and animal product is a major industry in the US.
*Ag. producers are concerned about the treatment of animals and take necessary actions to prevent abuse and neglect.
*The basic block of an animal's body is the cell.
*Through the process of mitosis, cells divide and reproduce to produce an animal.
*An animal's body is composed of a number of specialized cell that form tissues, organs, and system to preform specific functions.
*Reproduction begins with the creation of an embryo. Mammal embryos develop inside the mother's body. Avian embryos develop outside the mother's body.
*While the end result of digestion is the absorption of nutrients by the bloodstream, the process differs among species. So, food rations must be altered.
*Six different classes of nutrients are needed by an animal for optimum growth and development.
*A variety of feedstuffs is used in developing animal rations.
*Many traits and characteristics of an animal are passed to the animal through the genetic makeup of the animal's parents.
*Sperm and eggs are created through a process called meiosis in which each sperm and egg receive one-half of the chromosomes from the parent.
*Selective breeding is a process by which desirable characteristics are increased and undesirable characteristics are decreased.

TERMS

Animal rights – the rights of animals to be treated humanely
Animal welfare – the well-being of an animal
Artificial Insemination – a process of impregnating the female whereby sperm is placed in the female reproductive organs by means other than sexual intercourse
Digestive System – a system that breaks food into components small enough that they can be absorbed by the body
Embryo Transfer – a process of placing embryos into the female to cause pregnancy
Genetics – the genetic composition of an organism as it relates to heredity
Heredity – the total of genetic characteristics
Marketing – process of selling goods or services
Meiosis – a process of chromosomes' reduction in gamete-producing cells
Mitosis – a cell-dividing process in which 2 nuclei have the same number of chromosomes

Nutrient – a substance that gives nutrition
Processing – a process or treatment that changes an item into a consumable or a refined product for another process
Production – making goods usable
Roughages – food that is high in fiber
Ruminant – chewing and re-chewing what has been swallowed

Intro to Ag & ANR I

TERMS, REVIEW, AND QUESTIONS

TERMS

Annual – a plant with a life cycle that is completed in one growing season
Asexual reproduction – propagation utilizing a part or parts of one plant to produce others
Biennial – a plant that takes two growing seasons to complete its life cycle
Chlorophyll – green pigment in leaves
Fertilizer – material that supplies nutrients for plants
Flowers – reproductive part of the plant
Fungicides – a material used to destroy fungi
Germinate – a seed sprouting or starting to grow
Herbicides – a chemical for killing weeds
Insecticides – a material used to kill insects
Leaf – plant part consisting of a stipule, petiole and blade
Macronutrients – elements used in relatively large quantities
Micronutrients – elements used in very small quantities
Perennial – a plant that lives for more than two growing seasons
Photosynthesis – a process in which chlorophyll in green plants enables those plants to utilize light to manufacture sugar from CO_2 and H_2O
Phototropism – a process by which a plant leaf is capable of adjusting its angle of exposure to the sun
Propagation – process of increasing the number of a species
Respiration – a process in which energy and CO_2 are released due to digestion or the breakdown of plant tissues during periods of darkness
Roots – the part of the plant needed to anchor the plant to the ground
Sexual Reproduction – growing plants from seed
Stems – supports leaves and conducts flow of H_2O nutrients
Terminal bud – bud at the end of a twig or branch
Transpiration – a process by which a plant loses water vapor

REVIEW

*Flowering plants are composed of a system of roots, stems, leaves, and reproductive parts that function together to allow the plant to grow and produce food.
*The processes of respiration, photosynthesis, and transpiration allow a plant to take in nutrients and water and transform them into energy, oxygen and tissue.
*Plant growth takes place through the process of cell division, elongation, and differentiation.
*Seed are formed through a process of pollination in which pollen grains from the stamen fertilize ova in the pistil.
*Each part of a seed plays an important role in the development of the young plant.
*Seed germination is affected by a number of factors including temperature, moisture, light and oxygen.
*Plants require regular care for optimum growth and development.
*Plants can be formed through asexual means such as cutting, layering, separation and division, tissue culture and grafting.
*Life cycle is defined as the length of time over which a plant grows to maturity and is able to reproduce itself.
*The scientific classification of plants allows each animal to receive a specific formal name and shows relationships between and among different species.
*Sixteen essential nutrients are necessary in varying amounts for optimum growth and development in plants.

*The control of insects, diseases, and weeds in field crops is a major concern to producers because these pests reduce yields and cause losses.

Questions

How do the major parts of a flowering plant function together to cause the plant to grow, reproduce, and produce food?
How do the processes of respiration, photosynthesis, and transpiration work together in causing a plant to grow and reproduce?
How does a plant grow from a single cell to a complete plant?
What factors affect the process of seed formation?
How do the different parts of a seed contribute to plant growth and development?
How can seed germination rates be improved?
What types of care are needed for optimum plant growth?
What are the differences between asexual and sexual reproduction in plants?
What are the three most common life cycles in plants?
What is the scientific classification system, and why is it needed?
What are the essential nutrients required for optimum plant growth and development?
What are the different types of field-crop pests, and how does each type cause damage or loss to the crop?
What types of pest control methods exist, and what are their advantages and disadvantages?
How can producers develop the optimum plan for controlling pests in field crops?

Intro to Ag & ANR I

TERMS, REVIEW AND QUESTIONS

TERMS

Erosion – wearing away of the soil
Land capability class – classification that describes the best use of land
Leach – contents of soil removed downward into the soil by water
Microbes – microscopic plants or animals
Organic Matter – dead plant or animal matter
Permeable – permitting movement of material down into the soil
pH – degree of acidity or alkalinity
Soil – top layer of the soil
Soil profile – cross-section view of the soil
Texture – refers to the size and proportion of soil particles
Tillable – land or soil that is workable with tools or equipment

REVIEW

*Soil is the most important natural resource that must be protected and conserved.
*Soil is a naturally occurring substance that is formed over centuries through chemical and physical weathering processes.
*Soil texture refers to the amount of sand, silt, and clay particles that are present in the soil. Native soils are composed of different layers of materials.
*One important concept of soil conservation is that land can be classified according to its highest productive use.
*Factors that determine the highest productive use of a given plot of land include soil texture, slope, fertility, erosion potential, and internal drainage.
*An accurate soil test is important in determining the need for additional fertilizer and other soil amendments.
*As the pH of soil changes, the availability of existing nutrients in the soil changes.

QUESTIONS

•Why is soil an important natural resource?
•How is soil formed?
•How do I determine the texture of a soil?
•What are the different layers of the soil profile?
•What is the meaning of the term highest productive use?
•What factors determine the highest productive use of a plot of land?

•How do I obtain a representative sample of soil from a given area for testing purposes?
•How does the pH of a soil affect its productivity and fertility?
•How do I correct deficiencies in soil fertility?

ANR I
UNIT 7
ESSENTIAL QUESTIONS, REVIEW AND TERMS
TERMS

Regulator – a device that keeps pressure at a set level or controls the rate of flow of a gas or liquid
Neutral flame – flame with a balance of oxygen and acetylene
Tip cleaner – tool used to remove dirt or metal residue from a hole in tip of torch
Backfire – a loud snap or popping noise heard from torch when the flame blows out
Flashback – burning inside an oxy-fuel torch that causes the torch to squeal or hiss
Arc – flow of current across a narrow gap
Electrode – welding rod coated with flux and used with an electric welder
Tensile – the amount of tension or pull a weld can withstand
Electricity – form of energy that can produce light, heat, magnetism and chemical changes
Conductor – any material that will allow electrons to move through it
Resistance – any tendency of a material to prevent electrical flow
Insulator – material that provides great resistance to the flow of electricity
Volts – a measure of electrical pressure
Amps – a measure of rate of flow of current in a conductor
Watts – a measure of energy available or work that can be done using 1 ampere at 1 volt
Ohms – a measure of the resistance of a material to the flow of electrical current
Ignition – spark igniting an air fuel mixture
Exhaust – burned gases removed by the motion of the piston
Rpm – revolutions per minute
Stroke – the movement of the piston from the top to the bottom or the bottom to the top

REVIEW

*Safety is an integral part of daily life.
* Rules and regulations are essential to a safe work environment.
*Safe use and proper choice of tools is important to safely complete a welding job.
*Understanding common safety violations and the consequences of committing unsafe acts is important in the workplace.
*Typical applications of oxy-fuel welding and brazing are important.
*Safety procedure must be followed in oxy-fuel cutting.
*Identifying and correctly using personal protective devices is imperative in the welding craft.
*Welders should be able to identify and correct welding safety issues in the work environment.
*Welders should be able to exhibit a working knowledge of striking and extinguishing an arc using SMAW, GTAW and GMAW practices.
*Welders should be able to distinguish among horizontal, vertical, and overhead welding positions using SMAW, GTAW, and GMAW.

QUESTIONS

•What would happen if there were no rules and regulations?
•Why do we have safety rules and regulations?
•How do fires happen, and how do you extinguish a fire?
•What happens when you choose the improper tool for the job or use a tool in an incorrect manner?
•What is the difference between oxy-fuel and oxy-acetylene?
•How and where is oxy-fuel used in the welding area? Why do welders wear protective clothing?
•Why worry about electrical safety in welding?
•Why is it harder to strike an arc on low power supply current settings?
•How can you finish the weld without leaving a crater in the end of the bead?

ANR II

ESSENTIAL QUESTIONS, REVIEW AND TERMS

TERMS

Alternative energy – energy or fuel from new renewable or nonpolluting sources that are not widely used
Conservation – using natural resources wisely
Decomposer – an organism, such as a mushroom and bacterium, that breaks down the bodies of dead plants and animals
Domestic species – a species that is stronger or has some advantage over another species
Ecosystem – all the parts of a particular environment
Effluent – The water that flows from a treatment facility or factory into a stream, lake, or ocean
Exhaustible resources – a natural resource that cannot be increased; there are fixed quantities (coal, oil, etc.)
Industrial solid waste – waste from manufacturing
Inexhaustible resources – natural resources with a seemingly endless supply (wind, solar, etc.)
Renewable natural resources – a resource that can be replaced when it is used (air, soil, and wildlife)

REVIEW

*The atmosphere is a combination of gases, water vapor, and other materials that sustain life on earth.
*The atmosphere can be divided into distinguishable layer with each layer playing a different function.
*The relationship between the weather and the environment is complex.
*Climates can be defined using scientific factors such as latitude, longitude and temperature.
*The movement of the earth in orbit plays a major role in how weather patterns develop.
*Weather maps are used to predict and analyze the weather.
*Air quality is affected by the amount of foreign material in the air.
*Global pollution occurs through the movement of air.
*Air pollution comes from many sources.
*Air pollution can have a negative effect on the environment.
*Air pollution levels can be detected in the air around you.

Questions

•What is the atmosphere made of?
•What are the various layers of the atmosphere?
•How do the weather and the environment impact each other?
•How are climates defined?
•How does the movement of the earth affect weather fronts?
•What environmental factors are considered when analyzing the weather?
•How is air quality defined?
•How does global pollution occur?
•What causes air pollution?
•What are the effects of air pollution on the environment?
•How can air pollution be detected?

ANR II

TERMS, REVIEW, AND QUESTIONS

TERMS

Nonpoint source pollution – Pollution from sources that cannot be directly traced to any single point of discharge
Pathogens – living or non-living things that cause disease
Point source pollution – pollution that can be traced to a specific point of discharge
Potable water – water that is safe for humans to use for drinking or cooking
Stream – a flowing body of water
Stream flow – the volume and velocity of water movement in a stream
Stream hydrology – the study of flowing water and its environment

REVIEW

*The availability of water is dependent on its physical state.

*Water is classified based upon its salt content.
*Water is essential for all forms of life and is used for many purposes.
*Water comes from sources below and on the surface of the earth.
*The amount of water on the earth never changes.
*Flowing bodies of water have different characteristics than non-flowing bodies of water.
*Water pollution originates from both known and unknown sources of contamination.
*Water quality can be monitored by regularly testing the water for certain chemical indicators.
*Potable water can be consumed by humans.
*Wastewater is produced by agricultural, industrial, and residential sources.
*Wastewater can be hazardous to humans, animals, and the environment.
*There are various methods and treatments for wastewater management that prevent it from being a hazard to the environment.

QUESTIONS

•What is the chemical and physical makeup of water?
•How does the salt content of water affect its usefulness?
•Why is water so important?
•What is the difference between surface and groundwater?
•How does the water cycle work?
•What is the difference between flowing and non-flowing bodies of water?
•What causes water pollution?
•How do you test for the quality of water?
•What is potable water?
•Where does wastewater come from?
•What makes wastewater so hazardous?
•How is wastewater treated and handled?

ANR II

TERMS, REVIEW, AND QUESTIONS

TERMS

Annual Ring - the layer of wood produced by a single year's growth of a woody plant
Arboriculture – the cultivation of trees and bushes for study, ornamentation, or profit
Board Foot – a unit of volume for measuring lumber, equal to the volume of a board that is 1-ft square and 1-in. thick
Clear – cut to cut down and remove all of the trees from a forest or other area of land
Conifers – any tree that has thin leaves, needles, and produces cones; many types are evergreen; pines, firs, junipers, larches, spruces, and yews are conifers
Deciduous – describes trees and bushes that shed their leaves in the fall
Evergreen – describes a tree or bush that retains its foliage throughout the year
Hardwood – wood from a broad-leaved tree as opposed to from a conifer
Lumber – trees that have been sawed and prepared for use in building, woodworking, or cabinetmaking
Pulpwood – a soft wood that is used to make paper, (e.g., aspen, pine, or spruce)
Seedling – a young developing plant that has been grown from a seed
Silviculture – the study, cultivation, and management of forest trees
Softwood – the open-grained wood of a pine, cedar, or other coniferous tree

REVIEW

*A typical forest is structured in four layers: the canopy or overstory, the understory, the shrub layer, and the litter layer. Each layer plays a role in the growth and development of the total ecosystem.
*In Mississippi, the different species of yellow pine, as well as oak, hickory, and other hardwoods are economically important, furnishing wood and pulp for many different wood products.
*The number and size of the growth rings in a tree are indicators of the tree’s age and annual growth rate.
*Timber cruising is a process by which a representative sample of trees on a plot is measured and the volume of pulpwood and saw timber is estimated.

*Young seedlings must be planted in a manner that allows them to quickly establish a sound root system and begin to grow into merchantable timber. In planting young seedlings include proper depth of plants, proper placement of the root system and proper soil compaction. Wood products and by-products are used in many different ways to create consumer goods including lumber, paper and cardboard, posts and pilings, and foods and medicine.
*Biodiversity is a term related to the presence of a number of species of plants and animals. Forests encourage biodiversity by providing food and shelter for these species.
*Prevention of forest fires is preferable to control of fires. Prevention is achieved through a number of methods including prescribed burning and burn bans.
*Fire can damage standing timber by killing or damaging trees, consuming nutrients from the litter on the forest floor, and increasing the possibility of soil erosion.
*Reforestation is a major factor in the sustained use of forest land.

QUESTIONS

•How do the layers of a forest function to protect and enhance the ecosystem?
•What are the most economically important tree species in Mississippi, and how are products from these species used?
•How can the number and size of the growth rings of a tree be used to determine age and growth rate of the tree?
•How is an estimate of the volume of pulp and sawlog timber established?
•What procedures are used in planting young trees for reforestation?
•How do forest products affect our lives?
•How do forests promote biodiversity?
•What are some ways that forest fires can be prevented?
•How does fire cause damage to the forest and the environment in general?
•Why is reforestation important, and how is it accomplished?

ANR II

TERMS, REVIEW AND QUESTIONS

REVIEW

*Mississippi is home to a diverse number of aquatic and terrestrial wildlife species.
*All wildlife species require a habitat that provides food, water, shelter, and space for each species to survive and repopulate.
*Wildlife species play an important role in human life and in maintaining our environment.
*Wildlife habitat must be protected, managed and improved so that this important national resource can be conserved, sustained and renewed.
*Like any renewable natural resource, wildlife must be protected and conserved to maintain sustainability of each species.
*Because of declining populations, some wildlife species are now protected by being classified as protected, threatened, or endangered.
*Habitat management and hunting regulations, such as limiting hunting seasons, and imposing bag limits, are major tools in the conservation and protection of wildlife.

TERMS

Wildlife – wild animals, birds, and other living things, sometimes including vegetation, living in a natural undomesticated state
Vertebrae – bone in spinal column
Predator – carnivorous animal that hunts, kills, and eats other animals in order to survive, or any other organism that behaves in a similar manner
Prey – an animal or animals caught, killed, and eaten by another animal as food
Parasitism – symbiosis in which one organism lives as a parasite in or on another organism
Mutualism – relationship between two organisms of different species that benefits both and harms neither
Commensalism – the relationship between organisms of two different species in which one derives food or other benefits from the association while the other remains unharmed and unaffected
Wetlands – a marsh, swamp, or other area of land where the soil near the surface is saturated or covered with water, especially one that forms a habitat for wildlife

QUESTIONS

•What are the major species of wildlife in my community?

•What habitat does my community offer to different wildlife species?
•What are ways in which wildlife benefit humankind and the environment in general?
•How can habitat for wildlife be managed and improved?
•Why are wildlife conservation and protection policies and programs needed?
•What wildlife species are now considered to be nuisance, protected, threatened, endangered, or extinct? What is the difference between these categories?
•What are the major tools and practices for conserving, protecting, and managing wildlife?

ANR II

TERMS, REVIEW AND QUESTIONS

TERMS

Sustainable agriculture – exploiting natural resources without destroying the ecological balance of an area
E.P.A. – Environmental Protection Agency; a government agency charged with protecting the environment and human health
N.R.C.S – Natural Resources Conservation Service; government agency charged with conservation of soil and water resources in the United States
Composting – a mixture of decayed plants and other organic matter used by gardeners for enriching soil
Hazardous waste – waste that poses substantial or potential threats to public health or the environment
MSDS – Material Safety Data Sheet; accompanies chemicals to inform the user of the properties
Humus – dark brown organic component of soil that is derived from decomposed plant and animal remains and animal excrement

REVIEW

*Sustainable agriculture is a process for producing products economically and efficiently while maintaining the quality of life and the environment and conserving natural resources.
*Practices that promote sustainable agriculture include reduced tillage, integrated pest management, precision agriculture, fertilizer management, and protection of the soil.
*Many local, state and federal agencies play an important role in protecting and maintaining the environment by providing education and assistance to producers, monitoring production practices, and assisting environmental cleanup projects.
*Public laws and policies have been enacted to monitor and protect environmental quality promote the conservation of natural resources.
*Solid waste comes from many different sources and, if not properly disposed, can cause problems related to pests, public health and safety, and pollution of soil, air, and water.
*Recycling is the most environmentally friendly way of disposing of solid waste, but it is not practical for many forms of waste.
*A recycling program must include methods for collecting, sorting, storing, and disposal/sale of products.
*Composting is another environmentally friendly disposal method for non-hazardous organic materials.
*Hazardous waste is any product that has the potential for harming human health or the environment in general.
*Hazardous waste materials may cause harm by being ignited, reacting with other materials, corroding other materials, or posing a health hazard to humans or animals.
*Employers are required to have material safety data sheets available for employees that address the safe handling, storage, and disposal of any hazardous materials. The MSDS also contain information on the nature of the chemical substance, first aid measures, and steps to take in case of a spill.

QUESTIONS

•What is the difference between traditional agriculture production and sustainable agriculture?
•What are some key practices associated with sustainable agriculture, and how do they promote sustainability?
•What are some roles of government agencies and other organizations in protecting the environment and conserving natural resources?

•How do public laws and government policies protect the environment and promote the conservation of natural resources?
•What is solid waste, and how does it cause damage?
•How can solid waste be disposed?
•What is recycling?
•What is composting?
•What is hazardous waste, and how does it cause harm?
•Where can I obtain information about hazardous materials?

ANR II

ESSENTIAL QUESTIONS, REVIEW AND TERMS

TERMS

Regulator – a device that keeps pressure at a set level or controls the rate of flow of a gas or liquid
Neutral flame – flame with a balance of oxygen and acetylene
Tip cleaner – tool used to remove dirt or metal residue from a hole in tip of torch
Backfire – a loud snap or popping noise heard from torch when the flame blows out
Flashback – burning inside an oxy-fuel torch that causes the torch to squeal or hiss
Arc – flow of current across a narrow gap
Electrode – welding rod coated with flux and used with an electric welder
Tensile – the amount of tension or pull a weld can withstand
Electricity – form of energy that can produce light, heat, magnetism, and chemical changes
Conductor – any material that will allow electrons to move through it
Resistance – any tendency of a material to prevent electrical flow
Insulator – material that provides great resistance to the flow of electricity
Volts – a measure of electrical pressure
Amps – a measure of rate of flow of current in a conductor
Watts – a measure of energy available or work that can be done using 1 ampere
at 1 volt
Ohms – a measure of the resistance of a material to the flow of electrical current

REVIEW

*Proper management and maintenance of equipment extends the life of the machine, reduces failures and operating costs, and increases safety for operators.
*An important part of machinery management is the documentation of maintenance and repairs to the machine.
*Work orders for machinery maintenance and repair should detail the parts and supplies used and the amount of labor required.
*Preventive maintenance programs are designed to extend equipment life, reduce repair costs, and provide better safety for operators.
*In performing preventive maintenance, it is important to follow all safety procedures related to the use of tools and equipment, handling and disposal of hazardous materials, and personal protection.
*The owner's manual is the primary reference for planning and performing preventive maintenance on a regular schedule.
*Daily maintenance of equipment includes checking engine oil and transmission/hydraulic levels, checking tires, checking coolant levels, and visually inspecting the machine.
*Arc welding involves the use of high voltage electrical current and generates high temperatures and toxic fumes. The use of personal protective devices and safety precautions is essential to protect the health of the welder.
*The most common types of arc welders are the SMAW, GMAW, and GTAW. Each type has its strengths and limitations and can be used for several different types of welding.
*Welding accessories that must be used in arc welding include electrode holders, ground clamps, wire brushes, chipping hammers, and work clamps and guides.
*SMAW electrodes consist of a metal rod surrounded by a flux that shields the arc from outside air. Electrodes are classified by tensile strength, diameter, type of metal, and welding position.

*In setting up an arc welder of a given job, a welder must take into consideration the type and thickness of the metal being welded before selecting the appropriate electrode and setting the machine controls.
*Welds are classified as to type, joint, and position.
*In making a weld, the angle of the electrode, speed of the electrode travel, motion of the electrode, and machine settings must be controlled. Different welds and positions require different procedures.
*Mixtures of oxygen and acetylene gases are potentially explosive, and proper safety procedures and personal protection are necessary for same operation.
*The major parts of an oxyacetylene cutting unit are the cylinders, regulators, hoses, torch body, and cutting attachment.
*There is a set procedure for safely setting up, igniting, and shutting down an oxyacetylene torch unit that must be followed at all times.
*There are three different types of flames that can be generated by an oxyacetylene torch: oxidizing, neutral, and carbonizing.
*Making a cut with an oxyacetylene cutting torch involves preheating the metal and moving the torch in a steady smooth motion at the proper distance and speed across the metal.

QUESTIONS

•Why are machinery management and maintenance important?
•How are records of maintenance and repairs kept for a machine?
•How is a work order for machinery maintenance and repair completed?
•What are the purpose and goals of preventive maintenance?
•What safety procedures should be followed in performing preventive maintenance?
•What information can be found in an owner's manual regarding preventive maintenance?
•What items should be checked on a machine on a daily basis?
•What personal protection devices are necessary for safely using an arc welder?
•What safety procedures are necessary for safely using an arc welder?
•What are the most common types of arc welding machines, and where are they used?
•What accessories are used in arc welding, and what is their purpose?
•What factors must be taken into account in selecting a specific electrode for a job?
•What factors must be considered in setting up an arc welding machine for a specific job?
•What are the different weld types, joints, and positions?
•What factors must be taken into consideration in making a weld?
•What safety and personal protection procedures are necessary for oxyacetylene torch operation?
•What are the major parts of an oxyacetylene cutting unit?
•What is the procedure for setting up, igniting, and shutting down an oxyacetylene torch?
•What are the characteristics of the three different types of flames that can be generated by an oxyacetylene torch?
•What is the procedure for making a cut in mild steel with an oxyacetylene cutting torch?

ANR II

TERMS, REVIEW AND QUESTIONS

TERMS

Corporation – a company recognized by law as a single body with its own powers and liabilities, separate from those of the individual members
Partnership – the relationship between two or more people or organizations that are involved in the same activity
Sole proprietor – an individual who is the sole owner of a business that is neither a partnership nor a company
Wholesale – the business of buying goods in large quantities and selling them, especially to retailers for resale
Retail – the selling of goods directly to customers, (e.g., in stores)
Supply – to give, sell, or make available something that is wanted or needed by somebody or something
Interest – a charge made for a loan or credit facility, or a payment made by a bank or other financial institution for the use of money deposited in an account
Principle – finance relating to the initial amount of money that was invested or borrowed
Capital – money that can be used to produce further wealth
Depreciation – the amount or percentage by which something decreases in value over time, usually 1 year

Profit – the excess of income over expenditure, especially in business
Income Tax – a tax paid on money made from employment, business, or capita
Life insurance – a plan under which regular payments are made to a company during somebody's lifetime, and in return the company pays a specific sum to the person's beneficiaries after the person's death
Health Insurance – insurance to cover the costs or losses incurred if an insured person falls ill
Contract – a formal or legally binding agreement
Negligent – guilty of failing to provide a proper or reasonable level of care
GPS – Global Positioning System; a satellite-based navigation system that precisely identifies points on the earth

REVIEW

*Knowing what entrepreneurship means is necessary for a business.
*Society needs people who are willing to start business ventures.
*Each component of a business plan is important.
*There are many sources for funding a business venture.
*Having a plan for a business layout is needed when starting a business.
*The functions of management are important to a business's success.
*All companies have levels of management.
*The types of a business ownership used in society today are sole proprietorship, partnership, and corporation.
*Businesses are regulated by government in many ways.
*Risk management is important in a business setting.
*Insurance is very important in reducing risk.
*Insurance is a necessary means of protecting against loss.
*Insurance coverage is obtained through an insurance company or agent.
*An insurance agent will assist in the process of settling a loss.
*Speculative business risk should be identified for any business.
*GIS can be integrated into a variety of disciplines for solving problems.

QUESTIONS

•What does entrepreneurship mean?
•What are some business ventures that you might be interested in?
•What are the components of a business plan?
•What are some sources for funding a business?
•Why is your business layout so important?
•What are the seven functions of marketing?
•What are the functions of management?
•What are the levels of management?
•What must one do to prepare to own a business?
•What are the three types of business ownership?
•How are businesses regulated by the government?
•How can a business maintain or control risk?
•Why is insurance important to a business?
•What is insurance, and why do we need it?
•How would you obtain insurance coverage?
•What is the process of settling an insurance loss?
•How can GIS be used to solve problems in agriculture?

Health Science 1 Assignments for March 30th through April 3rd

1. Go to aeseducation.com and choose the anatomy and physiology lesson. Then choose the digestive system lesson. Fill out the electronic student worksheet while you do lesson 1 and 2. Take the digestive system quiz after reading both lessons.
2. Quizlet.com is an excellent source. My username is angiekentHS and you can choose digestive system to help you review terms.
3. Youtube.com video- https://youtu.be/Og5xAdC8EUI
4. You can reach me by email at akent@fcsd.k12.ms.us
5. Use and teach others all the infection control techniques you have learned.

Miss all of you and hope you are all doing well!!

Mrs. Kent

Unit 10: Digestive System

Name: ______________________________ Class: _________ Date: _______

Lesson 1: Digestive System

1. What are the functions of the digestive system? ______________________________
____
____
____
____

2. List the other names used for the digestive system. __________________________
____
____

3. Match the following terms with the correct definition.

Mastication	A. Swallowing
Bolus	B. Small piece of tissue hanging from the soft palate
Enzymes	C. The chewing process
Deglutition	D. Increase the rate of chemical reactions
Uvula	E. Chewed food mixed with saliva

4. What is the purpose of the epiglottis? ______________________________________
____

5. What is the esophagus and what does it do? What is peristalsis? ________________
____
____
____

6. What are sphincters? Name the two sphincters in the stomach and where they're located. ____
____
____

7. What is contained in chyme? ____
____

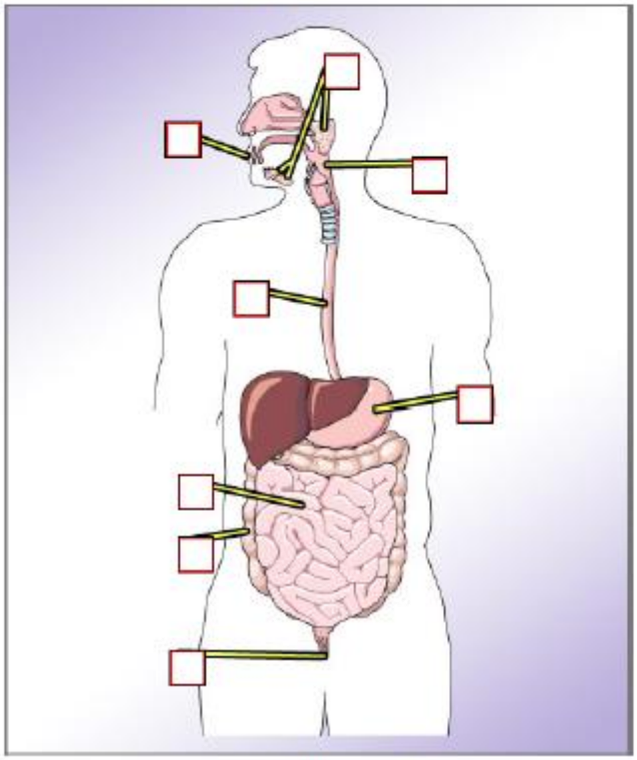
Name: ______________________________ Class: _________ Date: _______

8. Define the following terms relating to the small intestine:
   a. Duodenum - ______________________________
   ____
   b. Jejunum - ______________________________
   ____
   c. Ileum - ______________________________
   ____
   d. Villi - ______________________________
   ____
   e. Ileocecal valve - ______________________________
   ____
9. Define the following terms relating to the large intestine:
   a. Cecum - ______________________________
   ____
   b. Colon - ______________________________
   ____
   c. Rectum - ______________________________
   ____
10. What is Escherichia coli? What is its function? ______________________________
    ____
    ____
11. Where are most of the nutrients absorbed? Where is most of the water absorbed?
    ____
    ____

Name: ______________________________ Class: _________ Date: _______

12. Label the main parts of the digestive system.

- **A** Small Intestine
- **B** Mouth
- **C** Salivary Glands
- **D** Large Intestine
- **E** Esophagus
- **F** Pharynx
- **G** Stomach
- **H** Anus



13. What are the three accessory organs and their functions? ____________________

____

____

____

____

Unit 10: Digestive System

Name: ______________________ Class: _________ Date: _______

Lesson 2: Diseases and Disorders

1. What is an ulcer? What are the causes, symptoms and treatment? ________________

2. What is constipation? What are the causes, symptoms and treatment? _____________

3. What is inflammatory bowel disease (IBD)? What are the causes, symptoms and treatment? What are the two kinds of IBD? ________________________________

4. What is an eating disorder? What are the three examples of eating disorders?

Name: ______________________________ Class: __________ Date: ________

5. Explain what anorexia nervosa is, what demographic is most affected, and the health implications. ______________________________

6. Explain what bulimia nervosa is, what demographic is most affected, and the health implications. ______________________________

7. What is obesity caused by? What are the health implications? What are the three levels of obesity and how are they classified? ______________________________

8. What is diarrhea? ______________________________

Health Science 2 Assignments for March 30th through April 3rd

1. Go to aeseduction.com and choose patient comfort. You will then choose unit 7 oral care. You can fill out the student worksheet online and I can see the answers. Watch the PowerPoints for that unit, fill out the student worksheet, and take the quiz at the end of the lesson. There is also a skills checklist that you can read over.
2. You will also need to do unit 8 dressing and undressing (of a patient) on aeseducation.com. This is still located under patient comfort. Fill out the student worksheet that is available online and I can see your answers. You will then take the quiz at the end of the lesson. There is also a skills checklist that you can read over.
3. Use and teach others your infection control techniques you have learned.
4. If you need to reach me, you can email me at akent@fcsd.k12.ms.us

Miss seeing all of you! Stay safe and take care of yourself.

Mrs. Kent

Unit 8: Dressing and Undressing

Name: ______________________________ Class: ____________ Date: _______

Lesson 1: Dressing

1. Who should pick out the clothing that the patient wears? ____________________
2. Which side should you start with when dressing a patient? __________________

   ____
3. True or false: You undress the patient in the same order that they were dressed.

Lesson 2: Dressing with an IV

1. True or false: There is a special procedure for dressing patients with an IV.
2. What is done with the IV bag after removing it from the stand? ________________

   ____
3. Which arm is started with when undressing the patient? ____________________

Unit 7: Oral Care

Name: ______________________________ Class: ____________ Date: _______

Lesson 1: Oral Care

1. Why is proper oral care important? ____
   ____
2. Which patients need oral care more often? ______________________________
   ____
   ____
3. What personal protective equipment may need to be worn? ________________
   ____
4. What should assistants be watching for? ________________________________
   ____

Lesson 2: Special Oral Care

1. Who is special oral care given to? ______________________________________
2. What is used to rinse the patient's mouth? _____________________________
3. What is applied to the lips and tongue? _________________________________

Lesson 3: Denture Care

1. What are dentures? ____
2. ______________________ are similar to dentures and have small metal clips that hold them in place.
3. True or false: Dentures can be cleaned with a toothbrush and toothpaste.

Robotics and Engineering Year I and II (Option 1)

In this lesson you will calculate temperature using the Celsius and Fahrenheit formula. Refer to a YouTube video Temperature Conversions (Celsius and Fahrenheit). If you have any questions or concerns feel free to contact me through the Robotics and Engineering remind or my email dwilson@fcsd.k12.ms.us. If you would like to have a challenge, try Option 2 instead.

Temperature Scales Notes

Celsius – used in most of the world, except the ____________________

0 °C is the ____________________________ of water

100 °C is the ____________________________ of water

Converting from Celsius to Fahrenheit:

$$F = \frac{9}{5}C + 32$$

Examples:

Fahrenheit – used in the ____________________

32 °F is the ____________________________ of water

212 °F is the ____________________________ of water

Converting from Fahrenheit to Celsius:

$$C = \frac{5}{9}(F - 32)$$

Examples:

Robotics and Engineering Year I and II (Option 1)

Name: ______________________________ Class: ______

Temperature Conversion Practice

$$F = \frac{9}{5}C + 32$$

$$C = \frac{5}{9}(F - 32)$$

Convert to Celsius:

1.) 212 °F =

6.) 26 °F =

2.) 32 °F =

7.) 105 °F =

3.) 90 °F =

8.) 74 °F =

4.) 87 °F =

9.) 61 °F =

5.) 3 °F =

10.) 18 °F =

Convert to Fahrenheit:

11.) 100 °C =

16.) 10 °C =

12.) 0 °C =

17.) 33 °C =

13.) 50 °C =

18.) 89 °C =

14.) 25 °C =

19.) 15 °C =

15.) 95 °C =

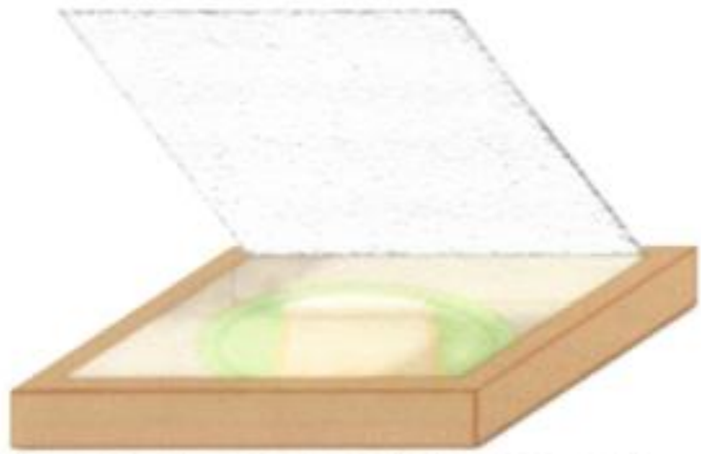
20.) 5 °C =

Robotics and Engineering Year I and II (Option 2)
Solar Oven Challenge

This is a lesson for some that would like to go a little beyond question and answer lesson. Your goal is to find materials at your house to create this solar oven. With this lesson you can use it to re-warm a food item or to test it to bake some cookies. Document your process and tell what was your end result. Tell how this process relates to the Greenhouse effect. Also, define these terms and state if they apply to this activity: radiation, insulator, conductor, convection, and conduction. You may search for an example of this lesson on YouTube. Just type in **How to Turn a Pizza Box into a Solar Oven.)**. If you have any questions or concerns feel free to contact me through the Robotics and Engineering remind or my email dwilson@fcsd.k12.ms.us

There is no better way to teach children about sun power than to have them construct a simple, yet powerful solar oven. This project makes an excellent science project.

Materials



- Cardboard pizza box
- Ruler
- Scissors
- Aluminum foil
- Clear tape
- Heavy-duty freezer bag
- Black construction paper
- Newspaper
- Wooden spoon

Instructions

1. Draw a square on the lid of the pizza box that is 1 inch smaller than the box on all sides.
2. Cut three sides of the square to make a flap.
3. Fold the flap so that it stands up when the lid is closed.
4. Cover the inside of the flap with aluminum foil, using tape to secure it to the cardboard.
5. Cut the freezer bag open along the seams.
6. Open the box lid and tape the freezer bag to the inside of the flap hole. This will create an airtight window for sunlight to enter the box.
7. Put black construction paper on the inside of the bottom of the box.
8. Roll up several sheets of newspaper and tape them around the inside of the box bottom. Be sure that the lid can still close.

Directions for Use

- Use the oven between the hours of 11 a.m. and 3 p.m. when the sun is highest.
- Adjust the flap until as much sunlight as possible is reflecting off of the foil to the window area.
- Use a ruler to keep the flap open at a right angle.
- Try buttering a slice of bread and placing cheese on top. Cook the bread in the oven on a clear glass or plastic plate.
- Be careful when taking the plate out of the oven; it will be hot.

Teacher Academy I & II

March 30th – April 3rd

A Note from Mrs. Larkin: Hello everyone! I hope these plans find you healthy and well. I am missing my kiddos something terrible! I hope you are taking this time to spend time with family and rest, but most of all I hope you are using precaution and staying safe. I am including some enrichment activities that directly relate the situation that we are in to the curriculum covered in our class. I encourage you to journal the answers to these prompts. These prompts will help you to critically think about the situation at hand and how the situation affects the school, students, and teachers. I miss you guys! …. Mrs. Larkin

Monday

- In light of the recent quarantine due to the pandemic, what obstacles do you believe that students may have experienced with online learning?

Tuesday

- If you were a teacher, what would concern you about students being at home instead of being at school during school hours?

Wednesday

- Do you think parents may view the role of a teacher differently now that students are learning at home? Explain how?

Thursday

- What could teachers do to better prepare themselves for online learning experiences?

Friday

- Make a list of basic supplies that you think students would need in case we encountered a situation like this again.

Module 29106-15 Lesson 2 Week of March 30 Welding 1

Name ____ **Date** _______________

MONDAY:

Match the following terms used to describe a filet weld from Section 2 page 16.

_____ 1. Shortest distance from the root of the weld to its face.

_____ 2. Distance from the root of the joint to the toe of a fillet weld.

_____ 3. Minimum distance minus any convexity from the root of the weld to its face.

_____ 4. Junction between the face of the weld and the base metal.

_____ 5. Point shown in a cross section at which the weld metal intersects with the base metal and extends fartherest into the weld joint.

_____ 6. Leg length at the largest right triangle that can be drawn within the cross section of a fillet weld.

_____ 7. The exposed surface of the weld.

_____ 8. Distance from the beginning of the joint (with zero opening) that is perpendicular to the hypothenuse of the largest triangle that can be inscribe within the cross section of a fillet weld.

A. Weld face
B. Leg
C. Weld toe
D. Weld root
E. Size
F. Actual throat
G. Effective throat
H. Theoretical throat

2. A fillet weld is unacceptable if it has any of the following six discontinuities. (page 16) Pay particular attention to the illustrations of each unacceptable fillet weld profile figure 12, on page 17, as you will have to recognize them on a quiz.

a. ____

b. ____

c. ____

d. ____

e. ____

Tuesday:

Read Section 2 and answer the following questions.

1. A ________________________ is a change or break in the shape or structure of a part that may or may not be considered a defect, depending on the code.

2. Codes and standards define the quality requirements necessary to ________________________________ ________________________________.

3. Weld discontinuities can prevent a weld from meeting the ________________________________.

4. How does AWS define a discontinuity? ________________________________ ________________________________ ________________________________.

5. The welder should be able to identify discontinuities and understand the effect they have on weld integrity. List the most common discontinuities mentioned in this module. ________________________________ ________________________________.

Wednesday:

6. ____________________ and ____________________ are weld defects that generally result from improper welding techniques.

7. ________________________ is the presence of voids and empty spots in the weld metal as a result of gas pockets trapped in the weld as it is being made and as the molten metal hardens, the gas pockets form voids.

8. List the four major types of porosity and define each. Page 10
   a. ____________________ ________________________________ ________________________________
   b. ____________________ ________________________________ ________________________________
   c. ____________________ ________________________________ ________________________________
   d. ____________________ ________________________________ ________________________________

9. ______________________ are foreign matter trapped in the weld metal between weld beads, or between the weld metal and the base metal.

10. With proper ________________________, along with the use of the correct ______________________ and ________________________________ inclusions can be avoided or kept to a minimum.

Thursday:

11. ________________ are narrow breaks that occur in the weld metal, in the base metal, or in the crater formed at the end of a weld bead.

12. The three basic cracks that occur in the weld metal are ________________ cracks , ______________________ cracks and ______________________ cracks.

13. The possibility of base metal cracks increases when using ____.

14. ____________________ cracks are limited mainly to steel and are usually found at regular intervals under the weld metal and usually do not extend to the surface.

15. ________________ cracks are generally the result of strains caused by thermal shrinkage acting on a heat affected zone that has been embrittled.

Friday:

16. _____________________________ occurs when the filler metal fails to penetrate and fuse with an area of the weld joint.

17. _______________________ is the failure of a welding process to fuse or join together with layers of weld metal or weld metal and base metal.

18. _________________________ is a groove melted into the base metal beside the weld.

19. Striking an arc on a base metal that will not be fused into the weld should be avoided because they create a defect known as ____________________________.

20. ____________________is made up of very fine particles of metal on the plate surface adjoining the weld area.

SECTION TWO

2.0.0 WELD DISCONTINUITIES AND THEIR CAUSES

Objective

Identify and describe weld discontinuities and their causes.

a. Identify and describe discontinuities related to porosity and inclusions.
b. Identify and describe discontinuities that result in cracking.
c. Identify and describe discontinuities related to joint penetration, fusion, and undercutting.
d. Identify and describe acceptable and unacceptable weld profiles.

Trade Terms

Arc blow: The deflection of an arc from its intended path by magnetic forces.

Defect: A discontinuity or imperfection that renders a part of the product or the entire product unable to meet minimum acceptable standards or specifications.

Discontinuity: A change or break in the shape or structure of a part that may or may not be considered a defect, depending on the code.

Embrittled: Metal that has been made brittle and that will tend to crack with little bending.

Hardenable materials: Metals that have the ability to be made harder by heating and then cooling.

Homogeneity: The quality or state of having a uniform structure or composition throughout.

Inclusion: Foreign matter introduced into and remaining in a weld.

Underbead cracking: Cracking in the base metal near the weld, but under the surface.

Codes and standards define the quality requirements necessary to achieve the integrity and reliability of a weldment. These quality requirements help ensure that welded joints are capable of serving their intended function for the expected life of the weldment. Weld discontinuities can prevent a weld from meeting the minimum quality requirements.

AWS defines a discontinuity as an interruption of the typical structure of a weldment, such as a lack of homogeneity in the mechanical, metallurgical, or physical characteristics of the material or weldment. A discontinuity is not necessarily a defect. A defect found during inspection will require the weld to be rejected. A single excessive discontinuity or a combination of discontinuities can make the weldment defective (unable to meet minimum quality requirements). However, a weld can have one or more discontinuities and still be acceptable.

The welder should be able to identify discontinuities and understand the effect they have on weld integrity. Some can be determined from visual inspection. Those that are internal to the weldment can only be detected through other testing methods. The most common weld discontinuities are the following:

- Porosity
- Inclusions
- Cracks
- Incomplete joint penetration
- Incomplete fusion
- Undercuts
- Arc strikes
- Spatter
- Unacceptable weld profiles

Ideally, a weld should not have any discontinuities, but most will have one or more. When evaluating a weld, it is important to note the type, size, and location of the discontinuity. Any one of these factors, or all three, can change a discontinuity into a defect, requiring the weld to be rejected during the inspection process. For example, discontinuities located at stress points tend to expand and thus have higher risk than those in other locations. Surface or near-surface discontinuities may be more harmful than similarly shaped internal discontinuities.

2.1.0 Porosity and Inclusions

Porosity and inclusions are weld defects that generally result from improper welding technique. Welders must recognize the causes of these defects and the techniques required to avoid them.

2.1.1 Porosity

Porosity is the presence of voids or empty spots in the weld metal. It is the result of gas pockets being trapped in the weld as it is being made. As the molten metal hardens, the gas pockets form voids.

Unless the gas pockets work up to the surface of the weld and burst open before the metal hardens, porosity cannot be detected through visual inspection.

Porosity can be grouped into the following major types:

- *Linear porosity* – May be aligned along a weld interface, the root of a weld, or a boundary between weld beads (*Figure 3[A]*).
- *Uniformly scattered porosity* – May be located throughout single-pass welds or throughout several passes in multiple-pass welds (*Figure 3[B]*).
- *Clustered porosity* – A localized grouping of pores that result from improperly starting or stopping the welding.
- *Piping porosity* – Normally extends from the root of the weld toward the face. These elongated gas pores are also called wormholes. They do not often extend to the surface, and the porosity cannot be visually detected (*Figure 3[C]*).

(A) LINEAR POROSITY

(B) SCATTERED SURFACE POROSITY

(C) PIPING POROSITY

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Figure 3 Examples of porosity.

Most porosity is caused by improper welding technique or contamination. Improper welding techniques may cause an inadequate amount of shielding gas to be formed. As a result, parts of the weld site are left unprotected. Oxygen in the air at the weld site, or moisture in the flux or on the base metal that dissolves in the weld pool, can become trapped and produce porosity.

The intense heat of the weld can decompose paint, dirt, oil, or other contaminants, producing hydrogen. This gas can become trapped in the solidifying weld pool and produce porosity.

Excessive porosity has a serious effect on the mechanical properties of the joint. Although some codes permit a certain amount of porosity in welds, it is best to have as little as possible. This can be accomplished by properly cleaning the base metal, avoiding excessive moisture in the electrode covering, and using proper welding techniques. Any porosity that occurs must be ground out until it is removed.

2.1.2 Inclusions

Inclusions are foreign matter trapped in the weld metal (*Figure 4*), between weld beads, or between the weld metal and the base metal. Inclusions are sometimes jagged and irregularly shaped. Sometimes they form in a continuous line. This concentrates stresses in one area and reduces the structural integrity (strength) of the weld.

Inclusions generally result from faulty welding techniques, improper access to the joint for welding, or both. A typical example of an inclusion is slag, which normally forms over a deposited weld. If the electrode is not manipulated correctly, the force of the arc will cause some of the slag particles to be blown into the molten pool. If the pool solidifies before the inclusions can float to the top, they become lodged in the metal, producing a discontinuity. Sharp notches in joint boundaries or between weld passes also can result in slag entrapment.

Inclusions are more likely to occur in out-of-position welding because the tendency is to keep the molten pool small and allow it to solidify rapidly to prevent it from sagging. Tungsten inclusions may occur in GTAW.

With proper welding technique, along with use of the correct electrode and the proper setting, inclusions can be avoided or kept to a minimum. Other preventive measures include the following:

- Positioning the work to maintain slag control
- Changing the electrode to improve control of molten slag

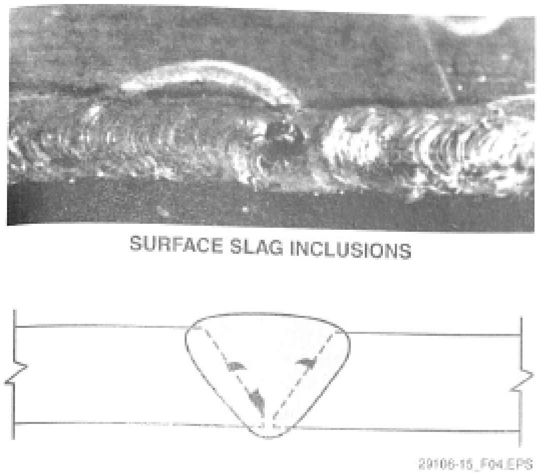


Figure 4 Examples of nonmetallic inclusions.

- Thoroughly removing slag between weld passes
- Grinding or sanding the weld surface if it is rough and likely to entrap slag
- Removing heavy mill scale or rust on weld preparations
- Avoiding the use of electrodes with damaged coverings

2.2.0 Cracks

Cracks are narrow breaks that occur in the weld metal, in the base metal, or in the crater formed at the end of a weld bead (*Figure 5*). Cracks occur when localized stresses exceed the ultimate strength of the metal. Cracks are generally located near other weld or base metal discontinuities.

2.2.1 Weld Metal Cracks

Three basic types of cracks can occur in weld metal: transverse, longitudinal, and crater. As seen in *Figure 5*, weld metal cracks are named to correspond with their location and direction.

Transverse cracks run across the face of the weld and may extend into the base metal. They are more common in joints that have a high degree of restraint.

Longitudinal cracks are usually located in the center of the weld deposit. They may be the continuation of crater cracks or cracks in the first layer of welding. Cracking of the first pass is likely to occur if the bead is thin. If this cracking is not eliminated before the other layers are deposited, the crack will progress through the entire weld deposit.

Case History

Mexico City Refinery

In Mexico City in 1984, a weld on a liquid propane gas (LPG) tank cracked. The escaping gas cloud drifted toward a nearby residential area until it encountered an ignition source. When the gas ignited, the fireball quickly burned its way back to the leak source. The resulting explosion destroyed the refinery and many residential neighborhoods, leaving 503 people dead and more than 4,000 injured.

The Bottom Line: Welds must be made correctly and inspected properly to prevent injury, loss of property, and sometimes death.

Crater cracks have a tendency to form in the crater whenever the welding operation is interrupted. These cracks usually proceed to the edge of the crater and may be the starting point for longitudinal weld cracks. Crater cracks can be minimized or prevented by filling craters to a slightly convex shape prior to breaking the welding arc.

Figure 6 shows various kinds of weld metal cracks. Weld metal cracking can usually be reduced by taking one or more of the following actions:

- Improve the contour or composition of the weld deposit by changing the electrode manipulation or electrical conditions
- Increase the thickness of the deposit and provide more weld metal to resist the stresses by decreasing the travel speed
- Reduce thermal stress by preheating
- Use low-hydrogen electrodes
- Balance shrinkage stress by sequencing welds
- Avoid rapid cooling conditions

2.2.2 Base Metal Cracks

Base metal cracking usually occurs within the heat-affected zone of the metal being welded. The possibility of cracking increases when working with hardenable materials. These cracks usually occur along the edges of the weld and through the heat-affected zone into the base metal. Types of base metal cracking include underbead cracking and toe cracking.

Underbead cracks are limited mainly to steel. They are usually found at regular intervals under the weld metal and usually do not extend to the surface. Because of this, they cannot be detected by visual inspection.

Hot and Cold Cracks

Hot cracks occur while the weld is solidifying. They can be caused by insufficient ductility at high temperature. Cold cracks occur after the weld has solidified. They are often caused by improper welding techniques.

Toe cracks are generally the result of strains caused by thermal shrinkage acting on a heat-affected zone that has been embrittled. They sometimes occur when the base metal cannot handle the shrinkage strains that are imposed by welding.

Base metal cracking can usually be reduced or eliminated by one of the following methods:

- Controlling the cooling rate by preheating
- Controlling heat input
- Using the correct electrode
- Controlling welding materials
- Properly matching the electrode filler metals to the base metals being welded

2.3.0 Other Discontinuities

In addition to those just described, there are several other types of discontinuities. Welders must learn to recognize these discontinuities, understand their causes, and learn the techniques required to avoid them.

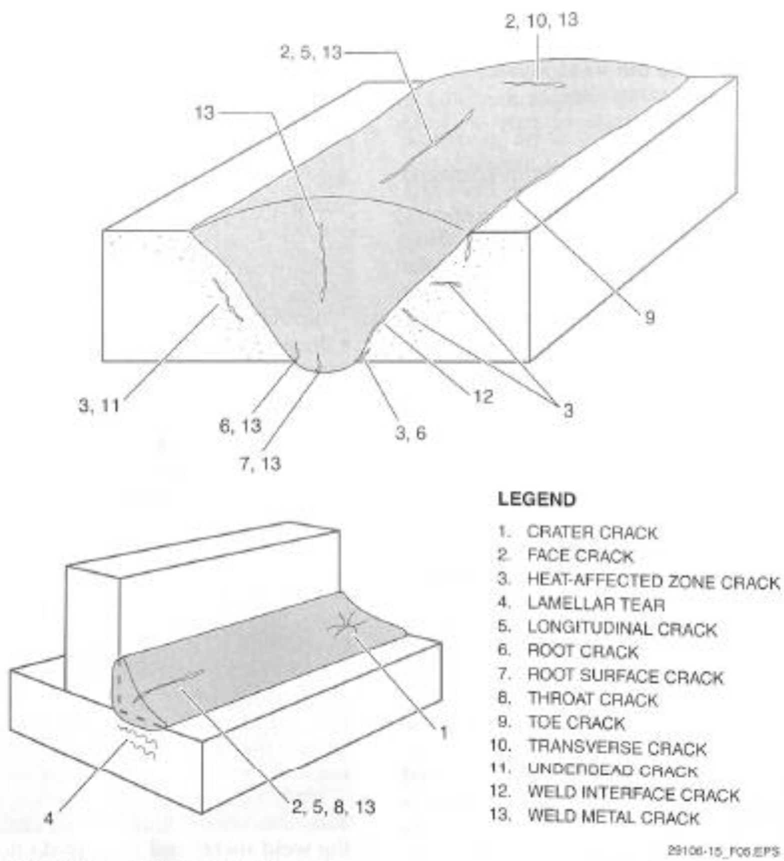


Figure 5 Types of weld metal and base metal cracks.

TOE CRACK

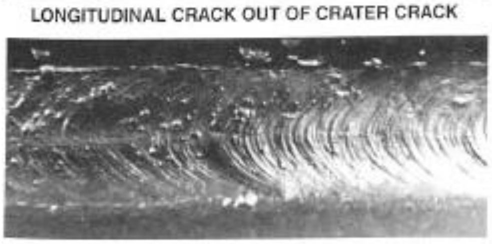
UNDERBEAD CRACK

TOE CRACK

LONGITUDINAL CRACK AND LINEAR POROSITY

CRATER CRACK

LONGITUDINAL CRACK OUT OF CRATER CRACK



FILLET WELD THROAT CRACK

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Figure 6 Examples of weld metal cracks.

2.3.1 Incomplete Joint Penetration

Incomplete joint penetration (*Figure 7*) occurs when the filler metal fails to penetrate and fuse with an area of the weld joint. Incomplete penetration will cause weld failure if the weld is subjected to tension or bending stresses.

Insufficient heat at the root of the joint is a frequent cause of incomplete joint penetration. If the metal being joined first reaches the melting point at the surfaces above the root of the joint, molten metal may bridge the gap between these surfaces and screen off the heat source before the metal at the root melts.

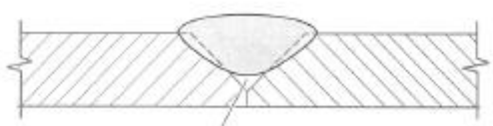
Improper joint design is another leading cause of incomplete joint penetration. If the joint is not prepared or fitted accurately, an excessively thick root face or an insufficient root gap may cause incomplete penetration. Incomplete joint penetration is likely to occur under the following conditions:

- If the root face dimension is too big, even though the root opening is adequate
- If the root opening is too small
- If the included angle of a V-groove is too small

Figure 8 is a labeled diagram showing correct and incorrect joint designs.

Even if the welding heat is correct and the joint design is adequate, incomplete penetration can result from poor control of the welding arc. Examples of poor control include the following:

- Using an electrode that is too large
- Excessive travel speed
- Using a welding current that is too low



INCOMPLETE
JOINT PENETRATION

INCOMPLETE
JOINT PENETRATION

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Figure 7 Incomplete joint penetration.

Incomplete penetration is always undesirable in welds, especially in single-groove welds where the root of the weld is subject either to tension or bending stresses. It can lead directly to weld failure or can cause a crack to start at the unfused area.

2.3.2 Incomplete Fusion

Many welders confuse incomplete joint penetration with incomplete fusion. It is possible to have good penetration without complete root fusion. Incomplete fusion is the failure of a welding process to fuse, or join together, layers of weld metal or weld metal and base metal.

Incomplete fusion may occur at any point in a groove or fillet weld, including the root of the weld. Often, the weld metal simply rolls over onto the plate surface. This is generally referred to as overlap. In many cases, the weld has good fusion at the root and at the plate surface, but because of poor technique and insufficient heat, the toe of the weld does not fuse. *Figure 9* shows incomplete fusion and overlap. Causes for incomplete fusion include the following:

- Insufficient heat as a result of low welding current, high travel speeds, or an arc gap that is too close
- Wrong size or type of electrode
- Failure to remove oxides or slag from groove faces or previously deposited beads
- Improper joint design
- Inadequate gas shielding
- Improper electrode angle
- Arc blow

Incomplete fusion discontinuities affect weld joint integrity in much the same way as porosity and slag inclusion.

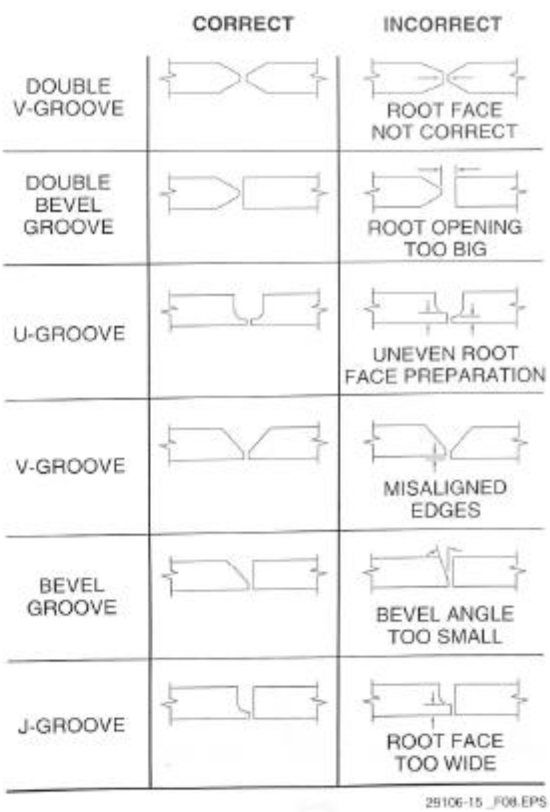

Figure 8 Correct and incorrect joint designs.

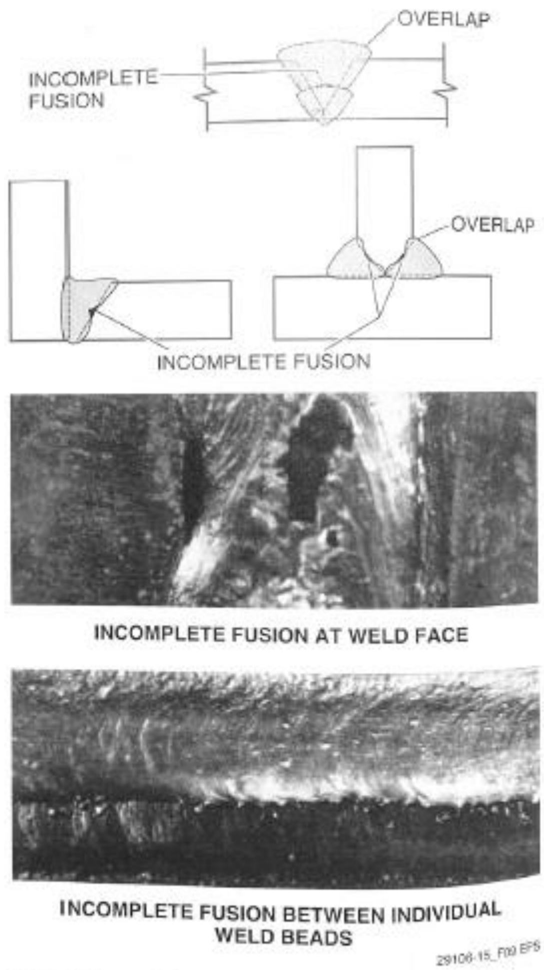

Figure 9 Incomplete fusion and overlap.

Undercut is a groove melted into the base metal beside the weld. It is the result of the arc removing more metal from the joint face than is replaced by weld metal. On multilayer welds, it may also occur at the point where a layer meets the wall of a groove (*Figure 10*).

Undercutting is usually caused by improper electrode manipulation. Other causes of undercutting include the following:

- Using a current adjustment that is too high
- Having an arc gap that is too long
- Failing to fill up the crater completely with weld metal
- Improper electrode angle
- Incorrect rod travel speed

Most welds have some undercut that can be found upon careful examination. When it is controlled within the limits of the specifications and does not create a sharp or deep notch, undercut is usually not considered a weld defect. However, when it exceeds the limits, undercutting can be a serious defect because it reduces the strength of the joint.

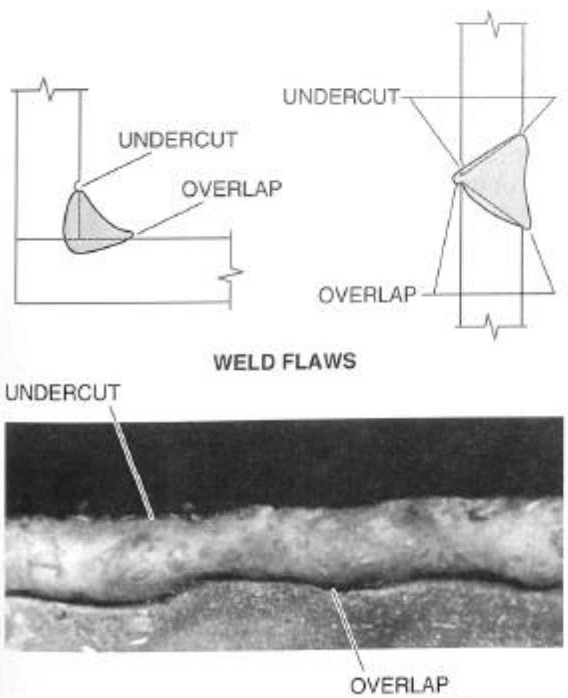

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Figure 10 Undercut and overlap.

Causes of Incomplete Joint Penetration

Incomplete joint penetration is generally associated with groove welds. It may result from insufficient welding heat, improper joint design (too much metal for the welding arc to penetrate), or poor control of the welding arc.

2.3.4 Arc Strikes

Arc strikes (*Figure 11*) are small, localized points where surface melting occurs away from the joint. These spots may be caused by accidentally striking the arc in the weld zone or by faulty ground connections. The weld zone is the area where the weld bead should be, and/or where the weld metal is to be deposited.

Striking an arc on base metal that will not be fused into the weld metal should be avoided. Arc strikes can cause hardness zones in the base metal and can become the starting point for cracking. Arc strikes can cause a weld to be rejected.

2.3.5 Spatter

Spatter is made up of very fine particles of metal on the plate surface adjoining the weld area. It is usually caused by high current; a long arc; an irregular and unstable arc; or improper shielding. Spatter makes a poor appearance on the weld and base metal and can make it difficult to inspect the weld. Spatter can also cause coating failure.

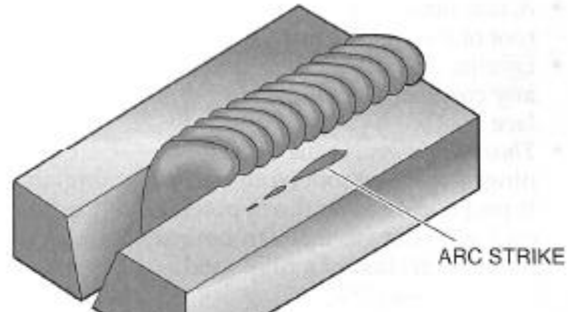

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Figure 11 Arc strike.

2.4.0 Acceptable and Unacceptable Weld Profiles

The profile of a finished weld can affect the performance of the joint under load as much as other discontinuities affect it. This applies to the profile of a single-pass weld and to a layer of a multiple-pass weld. An unacceptable profile for a single-pass or multiple-pass weld could lead to the formation of discontinuities such as incomplete fusion or slag inclusions as the other layers are deposited. *Figure 12* shows acceptable and unacceptable weld profiles for both fillet and groove welds.

2.4.1 *Fillet Welds*

A fillet weld is a weld that is approximately triangular in cross section and is used with T-, lap, and corner joints. The sizes and locations of fillet welds are given as welding symbols. The two types of fillet welds are convex and concave (*Figure 13*). A convex fillet weld has its surface bowed out like the outside surface of a ball. A concave fillet weld has its surface bowed in like the inside surface of a bowl.

The following terms are used to describe a fillet weld:

- *Weld face* – The exposed surface of the weld
- *Leg* – The distance from the root of the joint to the toe of a fillet weld
- *Weld toe* – The junction between the face of a weld and the base metal
- *Weld root* – The point shown in cross section at which the weld metal intersects with the base metal and extends farthest into the weld joint
- *Size* – The leg lengths of the largest right triangle that can be drawn within the cross section of a fillet weld
- *Actual throat* – The shortest distance from the root of the weld to its face
- *Effective throat* – The minimum distance, minus any convexity, from the root of the weld to its face
- *Theoretical throat* – The distance from the beginning of the joint root (with a zero opening) that is perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the cross section of a fillet weld.

Preferred Fillet Weld Contours

In single-pass, weave-bead fillet welds where two workpieces are being joined at an angle (not lap joints), flat or slightly convex faces are usually preferred because weld stresses are more uniformly distributed through the fillet and workpieces.

Fillet welds may be either equal leg or unequal leg (*Figure 14*). The face may be slightly convex, flat, or slightly concave. Welding codes require that fillet welds have a uniform concave or convex face, although a slightly non-uniform face is acceptable. The maximum convexity of a fillet weld or individual surface bead is dependent on the width of the weld face or individual surface bead, as follows:

- If the weld face or individual surface bead is ≤ 5/16" (8 mm), the maximum convexity is 1/16" (1.6 mm).
- If the weld face or individual surface bead is > 5/16" (8 mm) and < 1" (25 mm), the maximum convexity is 1/8" (3 mm).
- If the weld face or individual surface bead is ≥ 1", the maximum convexity is 3/16" (5 mm).

A fillet weld is unacceptable if the profile has any of the following discontinuities:

- Insufficient throat
- Excessive convexity
- Excessive undercut
- Overlap
- Insufficient leg
- Incomplete fusion

Fillet welds require little base metal preparation except for cleaning the weld area and removing all dross from cut surfaces. Any dross from oxyfuel, plasma arc, or carbon arc cutting will cause porosity in the weld. For this reason, the codes require that all dross be removed prior to welding.

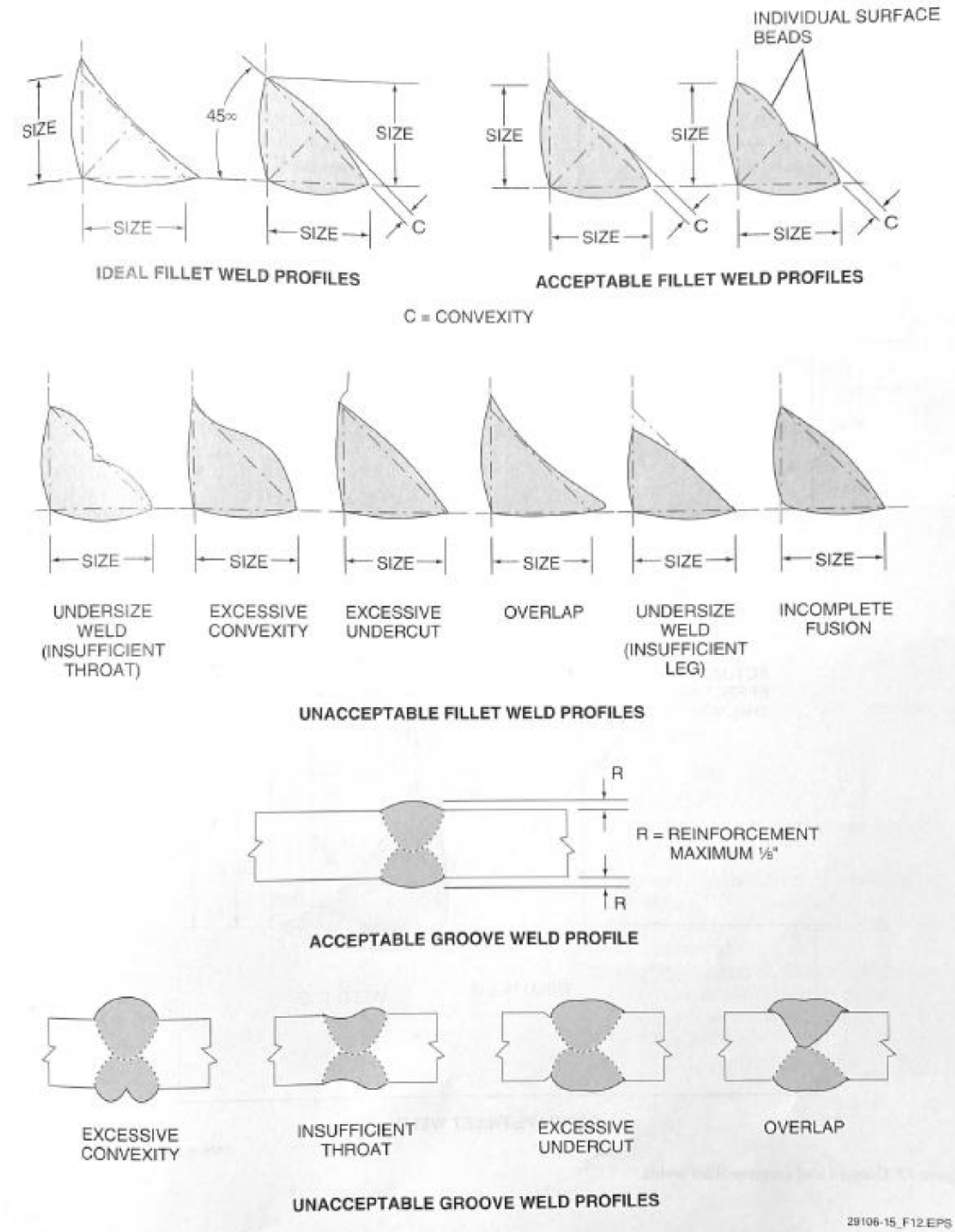


Figure 12 Acceptable and unacceptable weld profiles.

2.4.2 Groove Welds

Groove welds should be made with reinforcement not exceeding ⅛" (3.2 mm) and a gradual transition to the base metal at each toe. Groove welds should not have excess reinforcement, insufficient throat, excessive undercut, or overlap. If a groove weld has any of these defects, it is considered unacceptable. The bead width should not exceed the groove width by more than ⅛" (3.2 mm).

NOTE

Refer to your site's WPS for specific requirements on fillet and butt welds. The information provided here is only a general guideline. The site WPS or quality specifications must be followed for all welds. Check with your supervisor if you are unsure of the specifications for your application.

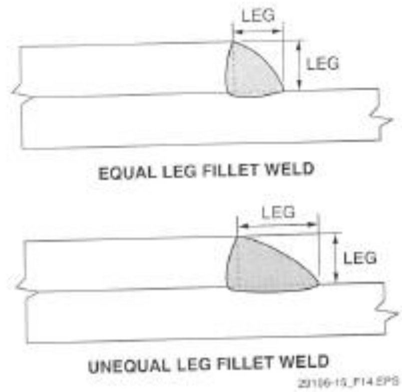


Figure 14 Equal leg and unequal leg fillet welds.

Additional Resources

Visual Inspection Workshop Reference Manual, AWS VIW-M-2008. Miami, FL: American Welding Society.

Welding Inspection Technology. Miami, FL: American Welding Society.

2.0.0 Section Review

1. The entrapment of gas pockets in a weld will cause ______.
   a. inclusions
   b. cracks
   c. porosity
   d. undercut

2. Which of these discontinuities *cannot* be detected by visual inspection?
   a. Toe cracks
   b. Underbead cracks
   c. Transverse cracks
   d. Face cracks

3. Undercut is usually caused by improper electrode manipulation.
   a. True
   b. False

4. Which of the following describes the leg of a weld?
   a. The shortest distance from the root of the weld to its face
   b. The junction between the face of the weld and the base metal
   c. The minimum distance, minus any convexity, from the root of the weld to its face
   d. The distance from the root of the joint to the toe of a fillet weld

Module 29207-15 GTAW Equipment and Filler Metals Week of March 30, 2020 Welding 2
Name ___________________________________ Date _____________

Monday:

Read Sections 2.0.0-2.20 and answer the following questions.

1. GTAW is a performed using constant current (CC) welding machines. The type of welding current DCEP or DCEN depends on ____. 2.1.0

2. Types of welding machines used for GTAW are (1) _____________________________________welding machines, (2) ____________________________________welding machines (3) ____ ______________________________ welding machines and (4) ____ ___________________________________welding machines. 2.1.0.

3. DC welding machines are usually designed to produce __________________________ ______________________ or ____________________________ ______________________________. 2.1.0

4. ____________________________ ______________________________ means that welding current is produced over a wide range regardless of arc length.

5. __________________________ ___________________________ means that voltage is constantly maintained as the output current varies.

6. ____________________________ welding machines produce only AC welding current. 2.1.1

7. In a transformer rectifier welding machine the ____________________________________ converts the high-voltage, low amperage welding current. The ____________________________ converts AC to DC. 2.1.2

8. Most high amperage machines designed specifically for GTAW are the _____________________________________ type. 2.1.2

9. _________________________________ sources increase the frequency of the incoming primary power and are used where space is limited and portability is important. 2.1.3

10. What is the advantage of an engine driven power source? ____ ____. 2.1.4

Tuesday:

11. Machine rating or size is determined by ___________________________ output. 2.1.5

12. The ____________________ ____________________________ is the percentage of a 10 minute period a machine can produce its rated amperage without overheating. If the _____________________________ is set below the rated amperage the duty cycle _____________________________________. 2.1.5

13. Cables used to carry welding current are designed for maximum ________________________________ and ______________________________________.2.1.6

14. The longer the distance current must travel the ________________________________ the cable must be. 2.1.6

15. With GTAW control of the welding current is often performed with remote controls such as __________________ _______________ or ___________________________________ switches and __________________________________. 2.17

16. Remote controls with only a switch can control one or more of the following. ______________________________, _______________________________, ______________________ and ______________________________________ 2.1.7

17. Remote controls with ___________________________ can be used to continuously vary the welding current as needed, from zero to maximum current set on the power source. 2.1.7

18. The most useful remote control has both switches and pointiometer, and controls the following 5 things.
____
____
____
_____________. 2.1.7

19. The GTAW torch provides an ____________________________________ for the welding current between the current lead and the tungsten electrode as well as passages for ____________________________________ or ____ if needed. 2.2.0

20. How is heat removed from GTAW torches?
____
____. 2.2.0

Wednesday:

Read Sections 2.3.0-2.5.8 and answer the following questions.

1. The GTAW ___________________________ shapes and directs the shielding gas flow as it exits the torch.

2. What are GTAW nozzles made of ? ____ 2.3.1

3. Nozzle size is given as a number such as 4, 6, 7, 8, or 12. These numbers are the nozzle openings diameters in multiples of 1/16. What is the diameter of a number 8 nozzle? _____________ 2.3.1

4. A GTAW torch may also be equipped with a ______________________________________ that contains an assembly of fine screens that straightens the gas flow from the nozzle and eliminates turbulence which causes the gas to flow smoothly past the tungsten electrode. 2.3.1

5. Why should you always handle tungsten electrodes with clean gloves? _________________________________
____

Thursday:

6. List seven different electrodes that are manufactured:

1. ____
2. ____
3. ____
4. ____
5. ____

6. ____

7. ____

7. Which type contains low-level radioactive thorium making grinding dust hazardous?
____

8. How are tungsten electrodes identified? ___________________________

9. List the Color code and AWS classification for the following electrodes:

Thoriated 1 percent____

2 percent____

Pure ____

Ceriated ____

Zirconiated ____

____

Lanthanated ____

____

____

10. GTAW process always uses _______________________ shielding gas. ______________________ is the most common. ___________________________ is used when deeper penetration and higher travel speeds are required.

Friday:

11. Filler metals are generally supplied in _______inch lengths and ______ to ______ diameter.

12. Carbon steel filler metals are identified by *AWS Specification* ____________ and low-alloy steel by *AWS Specification* _________.

13. How are filler metals marked? (fig 21) ____

14. Answer Section 2 Review Questions 1-5 page 30.

1. _______ 2. _______ 3. ______ 4. ______ 5. _______

Welding 2

SECTION TWO

2.0.0 GTAW EQUIPMENT

Objective

Identify and describe GTAW equipment and consumables.

a. Identify and describe GTAW welding machines.
b. Identify and describe GTAW torches.
c. Identify and describe GTAW torch nozzles and electrodes.
d. Identify and describe GTAW shielding gases.
e. Identify and describe GTAW filler metals.

Performance Tasks

1. Select a GTAW shielding gas.
2. Select a GTAW filler metal.
5. Break down and reassemble a GTAW torch.

Trade Terms

Potentiometer: A three-terminal resistor with an adjustable center connection; used for variable voltage control.

GTAW operations involve the use of a number of different types of equipment and consumables. Chief among these are GTAW welding machines, torches, nozzles, electrodes, shielding gases, and filler metals.

2.1.0 Welding Power Source Types

Welders use CC welding machines to perform GTAW. The type of welding current (DCEN, DCEP) depends on the type and thickness of the base metal.

Many types of welding machines may supply welding current for GTAW. Usually, any welding machine that produces constant current, such as those used for SMAW, can be used. In addition, there are welding machines specially designed for GTAW. These special machines have built-in high frequency and controls for shielding gas and cooling water. Types of welding machines that can be used for GTAW include the following:

- Transformer welding machines
- Transformer-rectifier welding machines
- Engine-driven generator and alternator welding machines
- Inverter power sources

DC welding machines are usually designed to produce either constant-current or constant-voltage direct welding current. Constant current means that welding current is produced over a wide voltage range regardless of arc length. This is typical of an SMAW or GTAW welding machine. A constant-voltage machine maintains a constant voltage as the output current varies. This is typical of a GMAW or FCAW welding machine. The output voltages and output currents of a welding machine can be plotted on a graph to form a curve. These curves show how the output voltage relates to the output current as either of these factors changes (*Figure 6*).

2.1.1 Transformer Welding Machines

Transformer welding machines produce alternating welding current only. They use a voltage step-down transformer, which converts high-voltage, low-amperage current from commercial power lines to low-voltage, high-amperage welding current. The primary electrical power input required for a transformer welder can be 120VAC, 208-230VAC single- or three-phase, or 460V three-phase. Special light-duty transformer welding machines used for sheet metal work are designed to be plugged into a 120VAC outlet. However, most light-duty transformer welding machines require 230VAC primary current. Heavy-duty industrial transformer welders require 460V three-phase primary current.

WARNING!

Coming in contact with the primary current of a welding machine can cause electrocution. Make sure that welding machines are properly grounded to prevent injury.

Transformer welders are not as common as other types of welding machines on the job site, but they are used for special jobs. A transformer welder has an On/Off switch, amperage control, and terminals for connecting the electrode lead and the workpiece lead. Transformer welding machines used for GTAW must have high-frequency capabilities built in or they must use an auxiliary high-frequency generator.

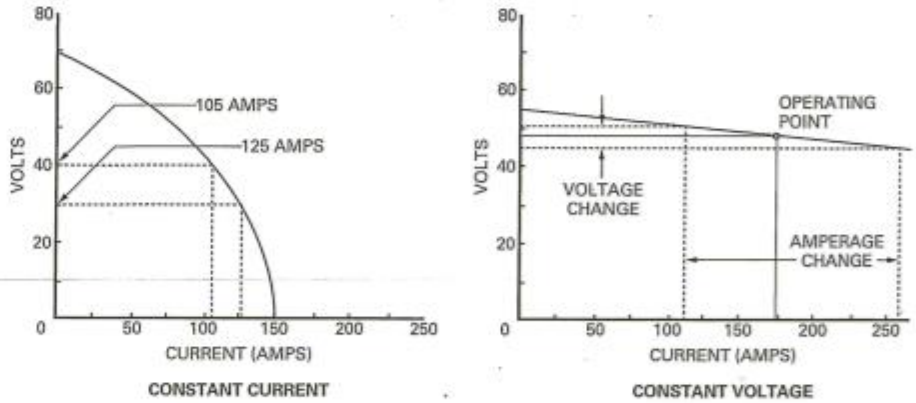


Figure 6 Constant-current and constant-voltage output curves.

2.1.2 Transformer Rectifier Welding Machines

The transformer-rectifier welding machine uses a transformer to transform the high-voltage, low-amperage primary current to low-voltage, high-amperage welding current and a rectifier to convert the AC to DC. Transformer-rectifier welding machines are designed to produce either direct welding current only or both alternating and direct welding currents. Small transformer-rectifier machines that produce both alternating and direct welding currents are usually lighter-duty than those that produce DC only. Transformer-rectifier welding machines that produce direct welding current only are sometimes simply referred to as rectifiers. Depending on their size, transformer-rectifier welding machines may require 120VAC, 208-230VAC single- or three-phase, or 460V three-phase power to operate.

Transformer-rectifiers used for GTAW have an On/Off switch and an amperage control. The welding cables (electrode lead and workpiece lead) are connected to terminals. They often have selector switches to select DCEN or DCEP. If there is no selector switch, welders must change the cables on the machine terminals manually to select the type of current desired. Most high-amperage machines designed specifically for GTAW are the transformer-rectifier type. Transformer rectifiers designed specifically for GTAW generally have the following:

- High-frequency generator
- High-frequency selector switch for DC Start, Continuous (for AC), or Off (no high frequency)
- Shielding gas preflow timer
- Control to automatically start cooling water flow when an arc is struck
- Shielding gas postflow timer control to prevent weld contamination (keeps shielding gas flowing for a set time after the arc has been terminated)
- Hand- or foot-operated remote current control
- Remote/local selector switch for remote control
- Start amperage control

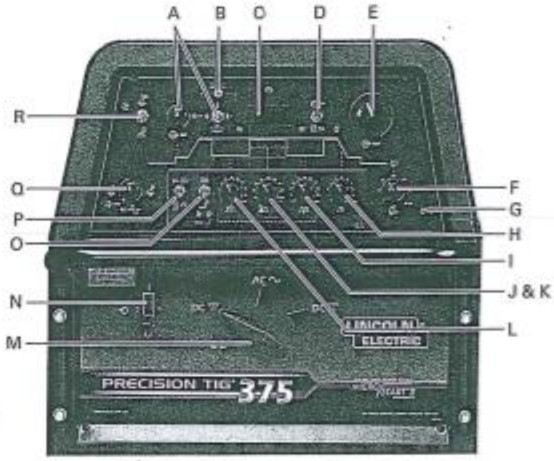
Welders often use GTAW for critical welds on difficult-to-weld materials. For this reason, many special advanced features and controls have been developed and are available on machines designed for GTAW. These advanced features and controls include the following:

- High-frequency intensity control for better arc starting
- High-frequency stabilizer control to control tungsten spitting
- Crater fill timer to automatically taper the welding current from the selected setting to a minimum current at the end of a weld
- Balanced wave adjustment for penetration/cleaning control (sets percentage of time AC remains on the straight or reverse side of the cycle)

Regardless of the machine used, welders should always consult the manufacturer's documentation for specific operating information. *Figure 7* shows a typical industrial, high-amperage, heavy-duty transformer-rectifier welding machine.

KEY CONTROLS

A. MINIMUM OUTPUT PRESET CONTROL & DISPLAY SWITCH
B. SET-UP MENU
C. DIGITAL AMPERAGE METER
D. LOCAL/REMOTE CURRENT SWITCH
E. MAXIMUM OUTPUT PRESET CONTROL
F. POST FLOW TIME
G. THERMAL SHUTDOWN LIGHT
H. DOWNSLOPE TIME
I. PULSE BACKGROUND CURRENT CONTROL
J. PULSE % ON TIME CONTROL
K. SPOT TIME
L. PULSE FREQUENCY CONTROL
M. POLARITY SWITCH
N. POWER SWITCH
O. PULSE/SPOT TIME MODE SWITCH
P. TRIGGER SWITCH
Q. AC BALANCE CONTROL
R. MODE SWITCH
S. REMOTE RECEPTACLE (NOT SHOWN)



SETUP MENU

- DC TIG START MODES: HIGH FREQUENCY, SCRATCH START, AND TOUCH START TIG™
- ADJUSTABLE PREFLOW TIME
- ADJUSTABLE START PULSE FOR SOFT OR FORCEFUL STARTS
- ADJUSTABLE TIG HOT START
- ADJUSTABLE UPSLOPE TIME
- ADJUSTABLE STICK HOT START
- ADJUSTABLE STICK ARC FORCE

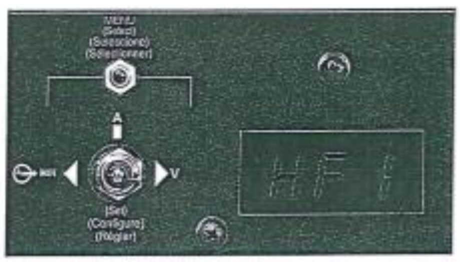


Figure 7 Transformer-rectifier welding machine designed for SMAW, GTAW, and pulsing.

2.1.3 Inverter Power Sources

Inverter power sources (*Figure 8*) increase the frequency of the incoming primary power. This provides a smaller, lighter power source with a faster response time and much more waveform control for pulse welding. Welders generally use inverter power sources in applications where space is limited and portability is important. The controls on these machines vary according to size and application.

The power source shown in *Figure 8* weighs less than 30 pounds (14 kg), and is a full-function inverter intended for alloy fabrication or critical maintenance work. It produces up to 90 amps with 100 percent duty cycle for GTAW, and 60 amps with 100 percent duty cycle for SMAW on an input power supply of 120VAC. However, it can produce up to 130 amps for both SMAW and GTAW when the input power is 208–230VAC.

Many production inverter welding machines used today are referred to as advanced inverter welding machines. They usually include all the controls listed for transformer-rectifier machines and basic inverter machines plus the following:

- Pulse arc control that allows the welding current to be pulsed between a high-current setting and a low-current setting for puddle control
- Hot-start current control to enable a controlled surge of welding current to establish a puddle quickly

1. STICK/TOUCH-START TIG/HF START TIG
2. 2-STEP/4-STEP TRIGGER INTERLOCK
3. DUAL RANGE PULSING
4. ADJUSTABLE PULSE FREQUENCY
5. ADJUSTABLE PULSE BACKGROUND CURRENT
6. ADJUSTABLE DOWN SLOPE
7. ADJUSTABLE POST FLOW
8. OUTPUT CONTROL
9. DIGITAL METER (PRESET/ACTUAL)
10. MS-TYPE REMOTE CONNECTOR
11. TWIST-MATE TORCH/GAS & WORK CONNECTIONS

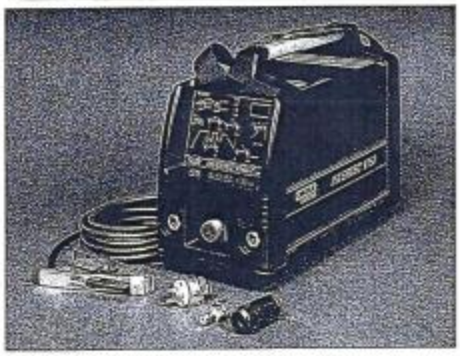


Figure 8 Basic GTAW inverter welding machine.

- Slope-up control for direct hot-start current, which controls how quickly the current rises to the hot-start setting
- Optional spot arc timer control for GTAW spot welding
- Variable AC-frequency control
- AC balance-wave control

Advanced inverter power sources are available in capacities of up to 500 amps that weigh approximately 100 pounds (45 kg).

2.1.4 Engine-Driven Generator Welding Machines

Welding machines can also be powered by gasoline or diesel engines. The engine can be connected to a generator or to an alternator. Engine-driven generators (*Figure 9*) produce direct welding current. Engine-driven alternators produce AC that is fed through a rectifier to produce direct welding current. The size and type of engine used depend on the size of the welding machine.

To produce welding current, the generator must turn at a required number of revolutions per minute. The engines powering the generators have governors that control the engine speed. Most governors have a welding speed switch that can be set to idle the engine when no welding is taking place. When the electrode is touched to the base metal, the governor automatically increases the speed of the engine to the required rpm for welding. If no welding takes place for about 15 seconds, the engine automatically returns to idle. The switch can also be set for the engine to run continuously at the welding speed.

Figure 9 Engine-driven generator welding machine.

Engine-driven generators often have an auxiliary power unit that produces 120VAC current for lighting, power tools, and other common equipment. When 120VAC current is required, the engine-driven generator must run continuously at the welding speed.

Engine-driven generators have engine controls and welding current controls. The engine controls vary with the type and size of the unit, but normally include the following:

- Starter
- Voltage gauge
- Temperature gauge
- Fuel gauge
- Hour meter
- Oil pressure indicator

The following are the common welding current controls:

- Amperage control
- Current range switch
- Amperage and voltage gauge
- Polarity switch

The advantage of engine-driven generators is that they are portable and can be used in the field where electricity is not available to power other types of welding machines. The disadvantage is that engine-driven generators are more costly to purchase, operate, and maintain.

2.1.5 Power Source Ratings

The rating of a welding machine is determined by the amperage output of the machine at a given duty cycle. The duty cycle of a welding machine is based on a 10-minute period. It is the percentage of ten minutes during which the machine can continuously produce its rated amperage without overheating. For example, a machine with a rated output of 300 amps with a 60-percent duty cycle can deliver 300 amps of welding current for 6 minutes out of every 10 without overheating.

The duty cycle of a welding machine will generally be 20, 30, 40, 60, or 100 percent. A welding machine having a duty cycle of 20 to 40 percent is considered a light- to medium-duty machine; welding can only be maintained for 2 to 4 minutes out of each 10-minute period. Most industrial, heavy-duty machines for manual welding have a 60- or 100-percent duty cycle rating. Machines designed for automatic welding operations have a 100-percent duty cycle rating.

With the exception of the 100-percent duty cycle machines, the maximum amperage that a welding machine can produce is always higher than its rated capacity. A welding machine rated for 300 amps with a 60-percent duty cycle generally puts out a maximum of 375 to 400 amps. However, since the duty cycle is a function of its rated capacity, the duty cycle will decrease as the amperage is raised over 300 amps. Welding at 375 amps with a welding machine rated for 300 amps with a 60-percent duty cycle will lower the duty cycle to about 30 percent. If welding continues for more than 3 out of 10 minutes under these conditions, the machine will overheat. Note that most welding machines have a heat-activated circuit breaker that will shut off the machine automatically when it overheats. The machine cannot be turned back on until it has cooled below a preset temperature.

Conversely, if the amperage is set below the rated amperage, the duty cycle increases. Setting the amperage at 200 amps for a welding machine rated at 300 amps with a 60-percent duty cycle will increase the duty cycle to 100 percent.

Figure 10 is a graph that shows the relationship between amperage and duty cycle.

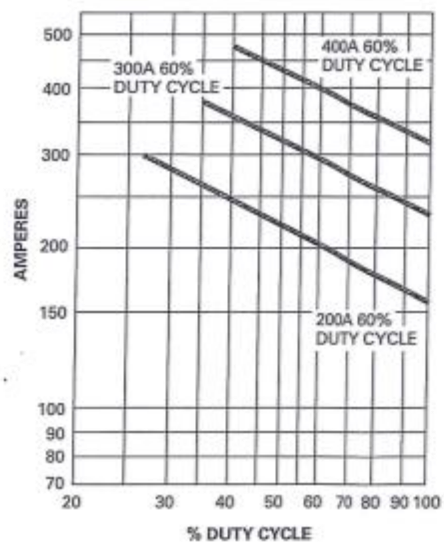


Figure 10 Relationship between amperage and duty cycle.

2.1.6 Welding Cable

Cables used to carry welding current are designed for maximum strength and flexibility. The conductors inside the cable are made of fine strands of copper wire. The copper strands are covered with layers of rubber reinforced with nylon or Dacron® cord. *Figure 11* shows the construction of a welding cable.

The size of a welding cable is based on the number of copper strands it contains. Large-diameter cable has more copper strands and can carry more welding current. Typically, the smallest cable size is number 4 and the largest is number 3/0 (spoken as "3 aught").

When selecting a welding cable size, consider the amperage load as well as the distance the current will travel. The longer the distance the current has to travel, the larger the cable must be to reduce voltage drop and heating caused by the electrical resistance in the welding cable. When selecting welding cable, use the rated capacity of the welding machine for the cable amperage requirement. For the distance, measure both the electrode and workpiece leads, and add the two lengths together. To identify the welding cable size required, refer to a table of recommended welding cable sizes. These tables are furnished by most welding cable manufacturers. Check all cable connections for tightness and repair loose or overheated lugs. If quick-disconnects are used, they must be properly sized to the cable or overheating may occur.

2.1.7 Remote Current Control

With GTAW, control of the welding current is often performed with remote controls such as foot- or hand-operated switches and **potentiometers**. Remote controls are generally designed for use with a specific welding machine, so they cannot be used universally on all machines. Remote controls with only a switch can control one or more of the following:

- High frequency
- Shielding gas
- Cooling water
- Welding current (on and off only)

Remote controls equipped with a potentiometer can be used to continuously vary the welding current as needed, from zero to the maximum current set on the power source.

Figure 11 Construction of a welding cable.

The most useful remote control has both switches and a potentiometer, and it controls the following:

- High frequency
- Shielding gas
- Cooling water
- Welding current (on and off)
- Welding current up or down as needed (zero to maximum setting on the power source)

Figure 12 shows various remote control units.

2.2.0 GTAW Torches

In addition to a CC welding machine (and a high-frequency generator for AC welding), GTAW requires the following:

- GTAW torch
- Shielding gas
- Optional torch cooling system

In addition, a remote amperage control is often used with GTAW. *Figure 13* shows a typical GTAW welding system.

Aluminum Welding with a Balled-Tip versus a Pointed-Tip Electrode

Traditional AC welding of aluminum using a balled-tip electrode is required for most applications using conventional power sources. However, for inverter power sources that use squarewave technology with AC balance and variable AC frequency control, welding thinner materials and creating smaller beads is accomplished much more easily using the same pointed and blunted 2 percent thoriated or ceriated electrodes as used for DCEN welding along with increased electrode-negative time.

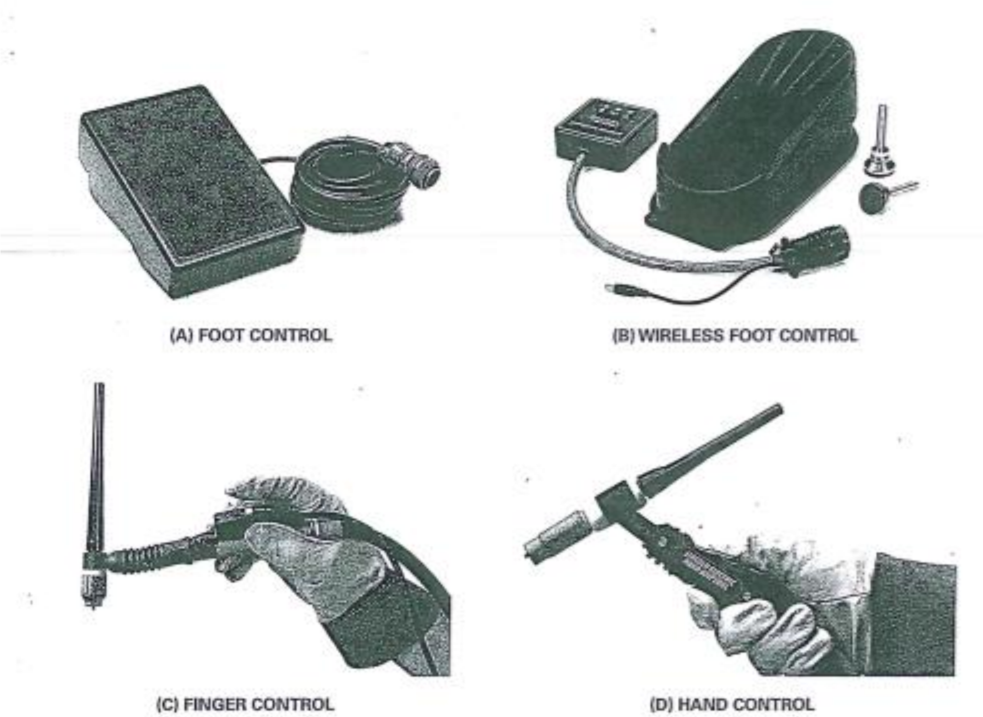


Figure 12 Typical foot-, hand-, and finger-operated remote controls.

The GTAW torch provides an electrical path for the welding current between the welding current lead and the tungsten electrode. There are many different manufacturers of torches, but all torches are basically the same even though their parts are not often interchangeable. All torch bodies have a built-in or replaceable collet body and electrode collet. The electrode collet and collet body come in a variety of sizes to match the size of the electrode being used. The collet holds the tungsten electrode in place and is secured by a back cap. The back cap, which is threaded onto the torch, is loosened to change the electrode or to adjust its stickout. The reserve length of electrode that extends from the back of the collet is insulated and protected by the back cap. Back caps are made in several lengths to cover tungstens of various lengths. The shorter back caps are used with short tungstens in confined spaces where torch clearance is inadequate.

The torch also contains passages for the shielding gas or cooling water, if needed. The shielding gas exits the torch through an insulated gas nozzle, sometimes called a cup, which surrounds the tungsten. *Figure 14* provides some GTAW torch terminology.

Heat is removed from GTAW torches either by air cooling with a shielding gas or by water cooling. *Figure 15* shows examples of both air-cooled and water-cooled GTAW torches. Two styles of air-cooled torches are common. One style uses a single plastic hose that has a power cable inside it, as shown in *Figure 15*. The shielding gas flows around the power cable, cooling it and the torch before being discharged to shield the electrode and weld. A special power cable adapter attaches to the power terminal on the power source.

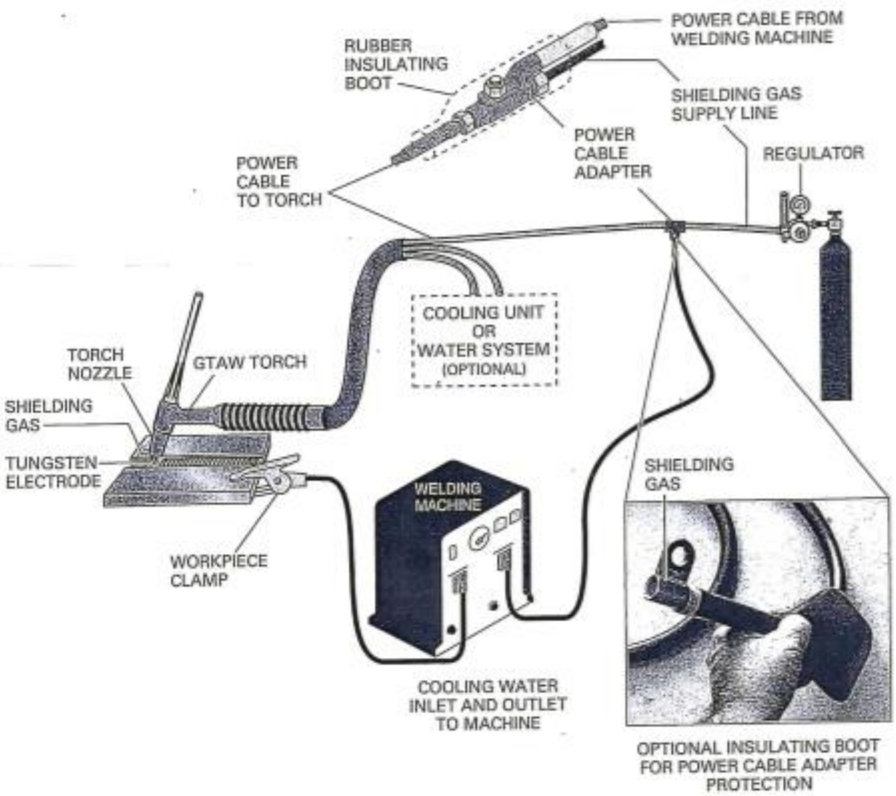


Figure 13 Basic GTAW welding system.

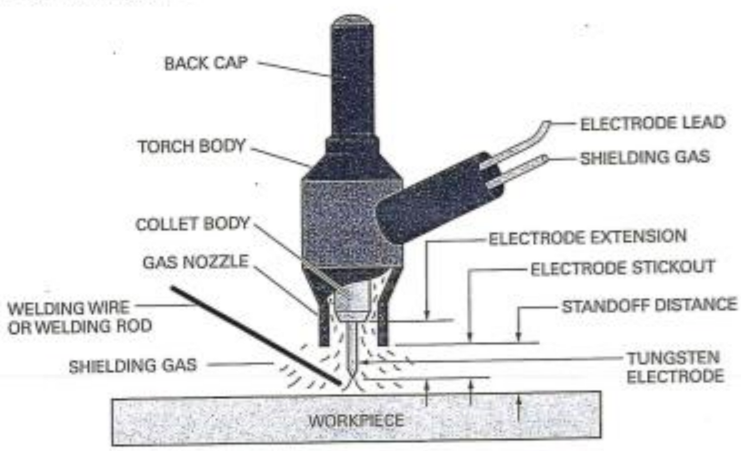


Figure 14 GTAW torch terminology.

This connector needs to be covered by a rubber insulating boot to prevent shorts. The single hose connects to one side of the adapter. This connection also makes the electrical connection. The shielding gas supply hose connects to the other side of the adapter.

AIR-COOLED GTAW TORCH

WATER-COOLED GTAW TORCH

Figure 15 GTAW torches.

The second type of air-cooled torch has a separate power cable and shielding gas hose. Either the single- or double-hose torch can be purchased with a gas control valve in the torch to manually control the shielding gas flow. This is necessary when the power source being used does not have a solenoid valve to automatically start and stop the shielding gas flow. *Figure 16* shows the various parts of an air-cooled GTAW torch.

Water-cooled torches have three hoses. One hose supplies shielding gas; one delivers cooling water to the torch; the third hose contains the power cable and the cooling water return or discharge. The cooling water may be supplied from the domestic water system or from a closed-loop cooling system. Regardless of the system used, it should include a fusible link in the torch cooling line. A fusible link is a temperature-based safety device that will open and stop the welding current flow if the coolant flow to the torch is interrupted. *Figure 17* shows the parts of a water-cooled GTAW torch.

Cable Covers

To prevent damage from hot or molten metal to GTAW torch cables containing hoses for gas or water, leather or fire-resistant cable covers can be added as protection. These covers zip or snap around the torch cable for a distance of 10" to 20" (25 cm to 50 cm) behind the torch handle.

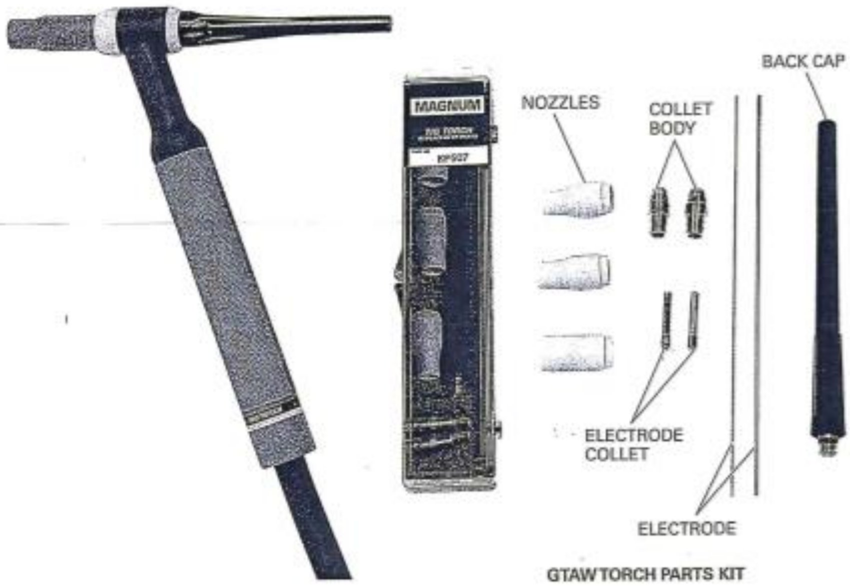


Figure 16 Air-cooled GTAW torch.

Closed-loop cooling systems recirculate demineralized water or special cooling fluids that will not corrode internal torch surfaces or plug the cooling passages with mineral scale. After cooling the torch, the water is typically returned to the system through a hose that also contains the torch power cable. A typical closed-loop cooling system usually consists of a reservoir, circulating pump, heat-transfer equipment to reject any collected heat to the atmosphere, and the connecting lines. The reservoir may also serve as the portable unit's base and be equipped with wheels for easy transport. *Figure 18* shows a closed-loop cooling unit. This particular unit is designed to stack with welding machines that have a matching chassis.

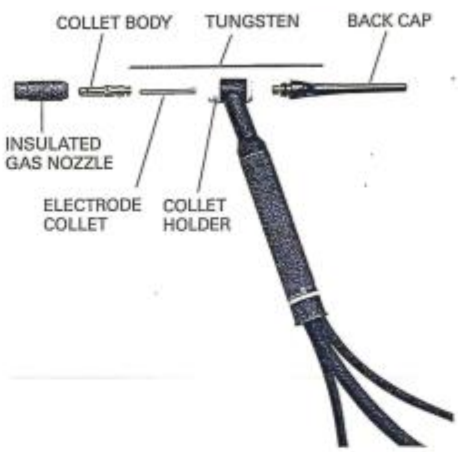


Figure 17 Water-cooled GTAW torch.

Figure 18 Typical closed-loop cooling unit.

2.3.0 Nozzles, Collets, and Electrodes

GTAW collets and electrodes are designed to work together, with the tungsten electrode fitting precisely into the collet. For this reason, welders must take both of the devices into consideration when selecting either the proper collet or electrode for a particular job.

2.3.1 Gas Nozzles

The GTAW gas nozzle shapes and directs the shielding gas flow as it exits the torch. Nozzles, sometimes called cups, are usually threaded onto the torch to form a gas-tight joint. They are made of ceramic material, chrome-plated steel, Pyrex®, or glass. Ceramic nozzles can be used up to about 300 amperes. Above that amperage, water-cooled, metal-coated ceramic nozzles or water-cooled ceramic nozzles must be used.

Gas nozzles are available in different lengths and diameters (refer to *Figures 16* and *17*). Nozzle length is determined by the job requirements, such as limited clearance or deep grooves. Nozzle size is the exit orifice inside diameter; it depends on the torch type and size and the electrode diameter. Nozzle size may be specified in fractions of an inch (¼", ⅜", 7/16", ½", ¾") or in millimeters (6 mm, 10 mm, 11 mm, 13 mm, 19 mm). Metric size nozzles are not, however, designed to be equivalent in size to imperial versions, and metric size and imperial size nozzles cannot be substituted for each other. Sometimes nozzle diameter is given as a size number, such as 4, 6, 7, 8, or 12. These numbers are the nozzle opening diameters in multiples of 1/16". For example, a Number 6 nozzle is 6 × 1/16", or ⅜" in diameter.

A GTAW torch may also be equipped with a gas lens collet body. A gas lens collet body contains an assembly of fine screens that straightens the gas flow from the nozzle and eliminates turbulence, which causes the gas to flow smoothly past the tungsten electrode. This reduces the chance that the turbulence will pull atmosphere into the weld zone and cause contamination and weld defects. The use of a gas lens allows longer tungsten stickout. This is useful for welding in tight quarters. Increasing tungsten stickout decreases the current-carrying capacity of the tungsten. *Figure 19* shows a typical gas lens collet body and torch with a nozzle, collets, and electrodes.

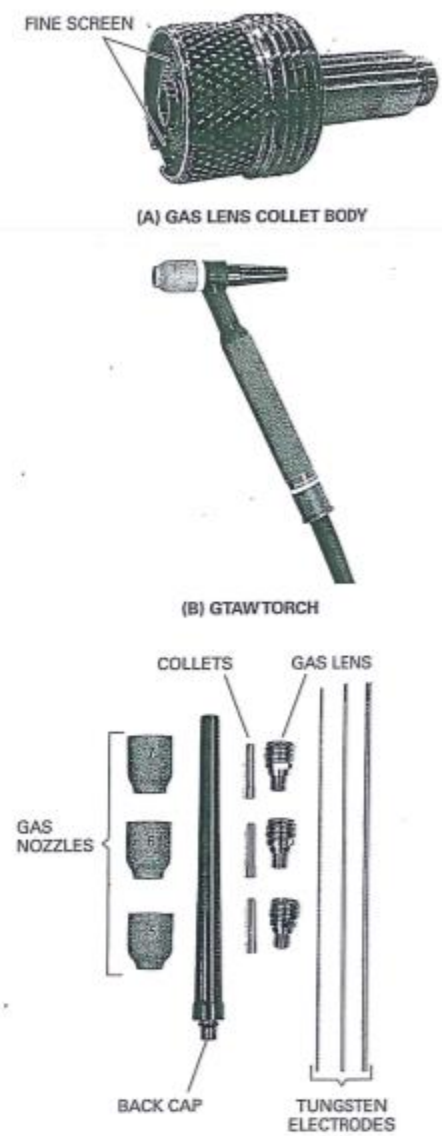


Figure 19 Typical gas lens collet body and torch with nozzle.

2.3.2 Tungsten Electrodes

Tungsten electrodes used for GTAW are manufactured in different formulations and sizes to meet the requirements of *AWS Specification A5.12*. Electrode diameters range from 0.01" (0.3 mm) up to ¼" (6.4 mm) for current ratings of 5 to 1,000 amperes. Electrodes are made in lengths of 3" (76 mm), 6" (152 mm), 7" (175 mm), 12" (305 mm), 18" (457 mm), and 24" (610 mm). Manual welding is usually done with 7" (175 mm) or shorter electrodes.

Electrodes are manufactured with two different finishes—chemically cleaned or ground. The ground finish is the more expensive option.

> Always handle tungsten electrodes with clean gloves to prevent contamination from body oils and other materials.

A number of different tungsten electrodes are manufactured. They include the following:

- Pure tungsten
- Zirconiated tungsten
- Thoriated tungsten
- Ceriated tungsten
- Lanthanated tungsten
- Rare earth tungsten
- Cryogenically treated thoriated tungsten

Pure tungsten electrodes, often simply referred to as tungstens, are used for AC welding. They provide good arc stability and good resistance against contamination. When used for DC welding, they are easily contaminated. Although relatively inexpensive in terms of per unit price, pure tungsten is more difficult to start, less able to maintain a stable arc, and has a shorter service life than other types of tungsten electrodes.

Zirconiated tungstens are also used for AC welding. They have a small percentage of zirconium added to the tungsten. They are used for AC welding where tungsten inclusions cannot be tolerated. The zirconium also gives these electrodes easy arc-starting characteristics.

Thoriated tungsten electrodes are used for DC welding. They have a small percentage of thorium added to do the following:

- Make the arc easier to start
- Increase the current range
- Help prevent tip melt
- Reduce the tendency to stick or freeze to the work
- Increase resistance to contamination, when properly used

Thoriated tungsten electrodes are most commonly manufactured in these two concentrations of thorium dioxide (thoria): EWTh-1 (approximately 1 percent thoria) and EWTh-2 (approximately 2 percent thoria).

> **WARNING!**
> Thoriated tungsten electrodes contain low-level radioactive thorium. The grinding dust from these electrodes is considered a hazard. *AWS Safety and Health Fact Sheet 27* provides further information about this subject. If possible, always use tungsten electrodes containing cerium or lanthanum instead of thorium.

Ceriated and lanthanated tungsten electrodes have the advantage of not being radioactive. Ceriated tungsten electrodes can be balled and used for AC welding.

EWG electrodes that combine three nonradioactive rare earth materials into one electrode are increasingly used as replacements for 2-percent thoriated electrodes. Besides their advantage of not being radioactive, these mixed tungsten electrodes start and re-ignite well and have very good service life for applications in which welding cycles of at least 15 minutes are used.

Thoriated electrodes that have been treated with a multi-step cryogenic process are another good replacement for 2 percent thoriated electrodes. The cryogenic treatment maximizes grain structure and improves electron flow. The cryogenically treated electrodes are easier to ignite and have longer tip life, longer overall electrode life, and higher amperage tolerance than nontreated 2-percent thoriated tungsten.

Gas Nozzles

Some manufacturers recommend that the inside diameter of the nozzle should be a minimum of three times the electrode diameter.

Think About It

Nozzle Size

What size nozzle would a welder select if a ½" diameter opening was needed?

Other tungsten electrodes continue to be developed. For example, tungsten electrodes with less common oxides, such as yttrium and magnesium, are also becoming available.

Tungsten electrodes are identified by a color band at one end. *Table 1* shows GTAW electrode color codes and AWS classifications.

2.4.0 Shielding Gas

The GTAW process always uses inert shielding gases to displace the atmosphere from the weld zone and prevent oxidation and contamination of the tungsten electrode, weld puddle, and filler metal. The two principal shielding gases used for GTAW are argon (Ar) and helium (He). The use of helium was what prompted the naming of GTAW initially as heliarc welding. These gases may be used alone or as mixtures. Occasionally, small percentages of other gases are added for special conditions.

Each shielding gas and shielding gas mixture has distinct performance characteristics. Each affects the arc differently and produces different weld characteristics. Mixtures of gases often have the best features of the individual gases within them. The following sections explain shielding gas characteristics and their principal uses.

Table 1 GTAW Electrode Color Codes and AWS Classifications

Electrode	Color Band	Electrode AWS Classification
Pure Tungsten	Green	EWP (Minimum 99.5% Tungsten)
1% Thoriated	Yellow	EWTh-1 (1% Thoria)
2% Thoriated	Red	EWTh-2 (2% Thoria)
Zirconiated	Brown	EWZr (0.15%–0.40% Zirconium Oxide)
Zirconiated	White	EWZr (8% Zirconium Oxide)
Ceriated	Gray	EWCe-2 (2% Ceria)
Lanthanated	Black	EWLa-1.0 (1% Lanthana)
Lanthanated	Gold	EWLa-1.5 (1.5% Lanthana)
Lanthanated	Blue	EWLa-2.0 (2% Lanthana)
EWG	*Not Standard	Undefined (*e.g.*, various combinations of rare earth alloys, yttrium oxide, magnesium oxide, etc.)

*Manufacturers may select any color not already in use.

2.4.1 Argon

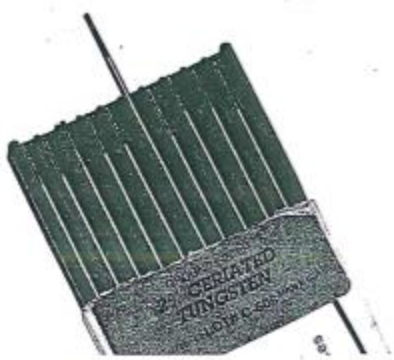
Argon is the most common shielding gas used with GTAW. Argon provides a smooth, quiet arc that requires a lower arc voltage than other shielding gases for a given arc length. This means that it gives the welder the greatest tolerance for arc gap variation. Argon also works well with AC, and it provides better base metal cleaning than helium. Argon is ten times heavier than helium, so it forms a better gas shield than helium, which tends to rise at the same flow rates. Argon is used both alone and in combination with other shielding gases.

When compared with helium, argon has the following advantages:

- A smoother, quieter arc
- Lower arc voltage for a given arc length
- Easier arc starting
- Better cathode cleaning on aluminum and magnesium with AC
- Lower shielding flow rate
- Better shielding in cross drafts
- Least expensive shielding gas

Tungsten Electrode Packaging

Most tungsten electrodes are packaged as shown to prevent contamination or damage to the electrodes. An inner divider containing the electrodes slides out of the package. Note the orange color band (may appear reddish due to printing color variations) on the end of each electrode, identifying the type in agreement with *Table 1*. All color bands typically discolor after use due to the heat produced. The color band end is not used when sharpening an electrode.



Small amounts of hydrogen are sometimes mixed with argon for deeper penetration in welding stainless steel. Hydrogen cannot be used with aluminum or carbon steels because it produces porosity and underbead cracking. The most common argon-hydrogen mixture is 85 percent argon and 15 percent hydrogen.

Nitrogen is sometimes added to argon to stabilize austenitic stainless steel and to increase penetration in welding copper.

2.4.2 Helium

Helium is used when deeper penetration and higher travel speed are required. Arc stability is not as good as it is with argon. However, helium is capable of delivering more heat on the base metal than is possible with argon, although it does require a higher voltage. This makes helium better for welding thick sections of highly heat-conductive metals such as aluminum and copper.

When compared with argon, helium has the following advantages:

- Deeper penetration into the weld joint
- Increased welding speed
- Welding of highly heat conductive metals

Helium is often mixed with argon. A common mixture is 75 percent helium and 25 percent argon. This mixture gives good cathodic cleaning action and deep weld penetration, which are good characteristics of both gases.

2.4.3 Cylinder Safety

Shielding gases may be supplied in bulk liqui tanks, in liquid cylinders, or in high-pressur cylinders of various sizes. The most commo container is the high-pressure cylinder, which i portable and can be easily moved as needed.

When transporting and handling cylinders observe the following rules:

- Always install the safety cap over the valve except when the cylinder has been connected for use.
- Secure the cylinder to prevent it from falling when it is in use. Chain or clamp it to the welding machine or to a post, beam, or pipe.
- Always use a cylinder cart to transport cylinders.
- Never hoist cylinders with a sling or magnets. Cylinders can slip out of the sling or fall from the magnets. Always use a hoisting basket or similar device.
- Always open the cylinder valve slowly, and open it completely to prevent leakage around the valve stem.

WARNING! Do not remove the valve's protective cap until the cylinder has been secured. If the cylinder falls over and the valve breaks off, the cylinder will shoot like a rocket, causing severe injury or death to anyone in its way.

Around the World

Tungsten Standards

The United States, Canada, Europe, and Japan each have their own published standards for tungsten, as shown in the table below. These standards specify the dimensions, packaging, and manufacturing requirements that tungsten manufacturers must meet for the given market area.

MARKET AREA	STANDARD NAME
UNITED STATES	ANSI/AWS A5.12
CANADA	ASME/SFA
EUROPE	ISO 6848
JAPAN	JIS

Always Use the Correct Gas

Make sure to always use the correct gas or gas mixture. Using an incorrect gas mixture, like a common one used for GMAW, which is 75 percent argon/25 percent CO^2, will immediately cause the tungsten electrode to be consumed and deposited in the weld as a contaminant. This is definitely not the kind of result you are looking for.

2.4.4 Gas Regulators/Flowmeters

A gas regulator and a flowmeter are required to supply the shielding gas to the torch at the proper pressure and flow rate (*Figure 20*). A typical regulator/flowmeter has a preset pressure regulator with a cylinder valve spud, a flow-metering needle valve, and a flow-rate gauge. The pressure regulator is usually equipped with a cylinder pressure gauge to indicate the cylinder gas pressure. The metering valve is used to adjust the gas flow to the torch nozzle. The flow gauge indicates the gas flow rate in cubic feet per hour (cfh) or liters per minute (L/min) as shown by a ball-type flow indicator. Although the regulator and flowmeter are shown separately in *Figure 20*, their functions may also be combined into a single device.

Gas flow to the torch is started and stopped either by a manually operated valve or by an electric solenoid valve. The manual valve may be on the torch, or it may be in the gas line to the torch. An electric solenoid valve is controlled automatically by the welding current flow or by a manual switch.

2.5.0 GTAW Filler Metals

Filler metal for manual GTAW is generally supplied in 36" (914.4 mm) lengths in diameters from 1/16" (1.6 mm) to 1/4" (6.4 mm). There are some automatic and manually operated wire feeders used with manual GTAW, but they are usually found only in high-production facilities. Filler metals for GTAW are drawn from high-grade pure alloys compounded for specific applications. Generally, the rods are not coated (bare, without a flux component added) except for a corrosion-resistant copper electroplating on some carbon steel rods. However, some special-purpose rods may have flux cores or coatings.

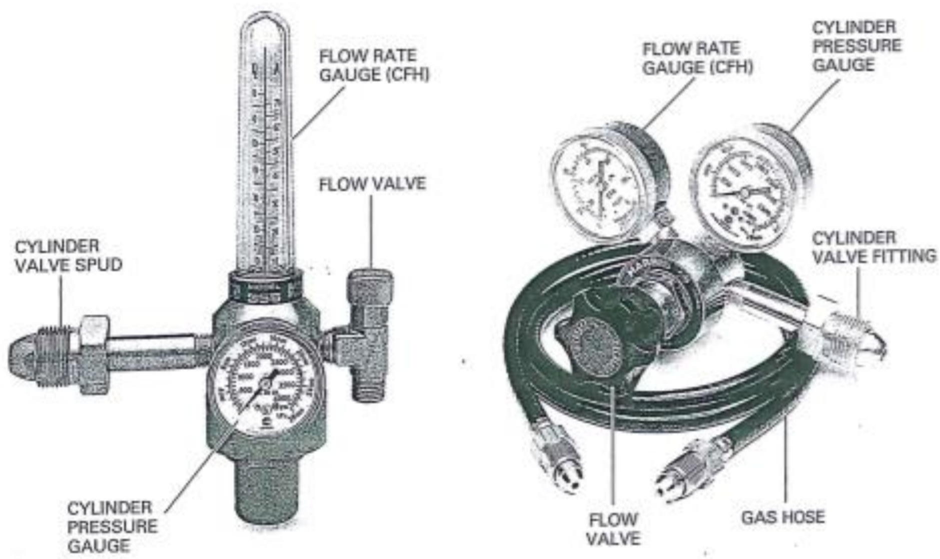


Figure 20 Shielding-gas flowmeter and gas regulator.

Several industry organizations and the United States government publish specification standards for filler metals. The most common standards are those published by the American Welding Society. The purpose of the AWS specifications is to set standards that all manufacturers must follow when manufacturing welding consumables. This ensures consistency for the user regardless of who manufactured the product. The specifications set standards for the following:

- Classification system, identification, and marking
- Chemical composition of the deposited weld metal
- Mechanical properties of the deposited weld metal

Examples of AWS specifications that apply to GTAW filler metals are the following:

- *AWS A5.7, Specification for Copper and Copper Alloy Bare Welding Rods and Electrodes*
- *AWS A5.9/A5.9M, Specification for Bare Stainless Steel Welding Electrodes and Welding Rods*
- *AWS A5.10/A5.10, Specification for Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods*
- *AWS A5.14/A5.14M, Specification for Nickel and Nickel Alloy Base Welding Electrodes and Rods*
- *AWS A5.16/A5.16M, Specification for Titanium and Titanium Alloy Electrodes and Rods*
- *AWS A5.18/A5.18M, Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*
- *AWS A5.19, Specification for Magnesium Alloy Welding Electrodes and Rods*
- *AWS A5.22, Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding*
- *AWS A5.28/A5.2, Specification for Low Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*

NOTE

The specification number is generally followed by a colon and then a four-digit number, such as A5.18:2005 or A5.28:2015. The colon and following number indicate the year that the specification was last revised. These documents are revised periodically, usually every five years. For that reason, the year numbers have been omitted from the specifications cited in this module. When referring to an AWS specification on the job, always make sure to use the current version.

Filler metals and wire are graded for three major areas of use:

- *General use* – The wire or rod meets specifications. No record of chemical composition, strength, etc., is supplied to the user with the wire purchase.
- *Rigid control fabrication* – A Certificate of Conformance is supplied with the wire or rod at purchase. The stock is identified by heat numbers or code numbers located on the roll package.
- *Critical use* – A Certified Chemical Analysis report is supplied, and records are kept by the fabricator of welds and processes for later reference on aircraft, nuclear reactors, and pressure vessels.

Factors that affect the selection of a GTAW filler metal include the following:

- Base metal chemical composition
- Base metal mechanical properties
- Weld joint design
- Service or specification requirements
- Shielding gas used

The following are commonly used filler metal types:

- Carbon steel
- Stainless steel
- Aluminum and aluminum alloy
- Copper and copper alloy
- Low-alloy steel

Table 2 summarizes the GTAW filler metal specifications and the major AWS class covered by each specification.

Gas Cylinders

Gas cylinders must always be handled with great care because of the high-pressure gases they contain. If the valve is broken off a high-pressure gas cylinder, the gas will escape with explosive force, which can cause severe injury from the blast and blown debris. The cylinder itself may become a deadly missile. The tanks must always be chained in an upright position when being transported or positioned in their storage or use locations.

Table 2 GTAW Filler Metal Specifications and Classification System

Material	Filler Metal		X Designator Description	Example
	AWS Spec.	AWS Class*		
Carbon steel	A5.18	ERXXS-Y EXXC-Y	Tensile strength × 1,000 (psi)	ER70S-3 E70C-3
Low-alloy steel	A5.28	ERXXS-Y EXXC-Y	Tensile strength × 1,000 (psi)	ER80S-B2 E80C-B2
Stainless steel	A5.9	ERXXXY	Stainless alloy (308, 410, etc.)	ER308L EC308L
Stainless steel (flux-cored)	A5.22	RXXXTI-5	Stainless alloy (308, 309, etc.)	R309LT1-5
Aluminum	A5.10	ERXXXX-Y	Aluminum alloy (4043, 5083, etc.)	ER4043
Nickel	A5.14	ERNIXX-Y	Major alloying elements (Cr, Fe, Mo, etc.)	ERNiCr-3
Copper	A5.7	ERCuXX-Y	Major alloying elements (Al, Ni, Si, etc.)	ERCuAl-A2
Magnesium	A5.19	ERXXYYY	Major alloying elements (Al, Zn, etc.)	ERAZ92A
Titanium	A5.16	ERTI-Y		ERTI-5

*Legend

E – Filler metal may be used as an electrode.

R – Filler metal may be used as a rod.

S – Solid filler metal.

C – Composite or stranded filler metal.

Y – Designator (or combination of designators) that describes specific alloy, shielding gas to be used, diffusible hydrogen limit, etc. Refer to the appropriate AWS Filler Metal Specification shown in table for explanation.

The AWS classification of metal filler rod is identified on its container. In addition, each rod is usually marked either by stamping the AWS classification into the rod or by a paper or plastic tab wrapped around the rod (*Figure 21*). Consume filler metal rods so that the ID marker is not destroyed. Markers are located at each end. Cutting a rod in half allows you to retain the marker on the used stub. Retaining the stubs with the markings until the weld is complete provides evidence that the correct filler metal was used.

2.5.1 Carbon Steel and Low-Alloy Steel Filler Metals

Carbon steel filler metals are identified by *AWS Specification A5.18*. Low-alloy steel filler metals are identified by *AWS Specification A5.28*. The rod classification number is found on a label on the packaging. *Figures 22* and *23* show the AWS classifications for carbon steel and low-alloy steel filler metals.

All steel filler metals contain alloys such as silicon, manganese, aluminum, and carbon. Other alloys such as nickel, chromium, and molybdenum are also often added. The purpose of the alloys is as follows:

- *Silicon (Si)* – Concentrations of 0.40 to 1.00 percent are used to deoxidize the puddle and to strengthen the weld. Silicon above 1 percent may make the welds crack-sensitive.
- *Manganese (Mn)* – Concentrations of 1 to 2 percent are also used as a deoxidizer and to strengthen the weld. Manganese also decreases hot-crack sensitivity.
- *Aluminum (Al), Titanium (Ti), and Zirconium (Zr)* – One or more of these elements may be added in very small amounts for deoxidizing. These elements may also increase strength.
- *Carbon (C)* – Concentrations of 0.05 to 0.12 percent are used to add strength without adversely affecting ductility, porosity, or toughness.
- *Nickel (Ni), Chromium (Cr), and Molybdenum (Mo)* – These elements may be added in small amounts to improve corrosion resistance, strength, and toughness.

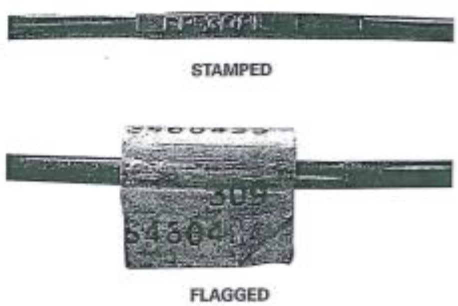


Figure 21 Filler rod markings.

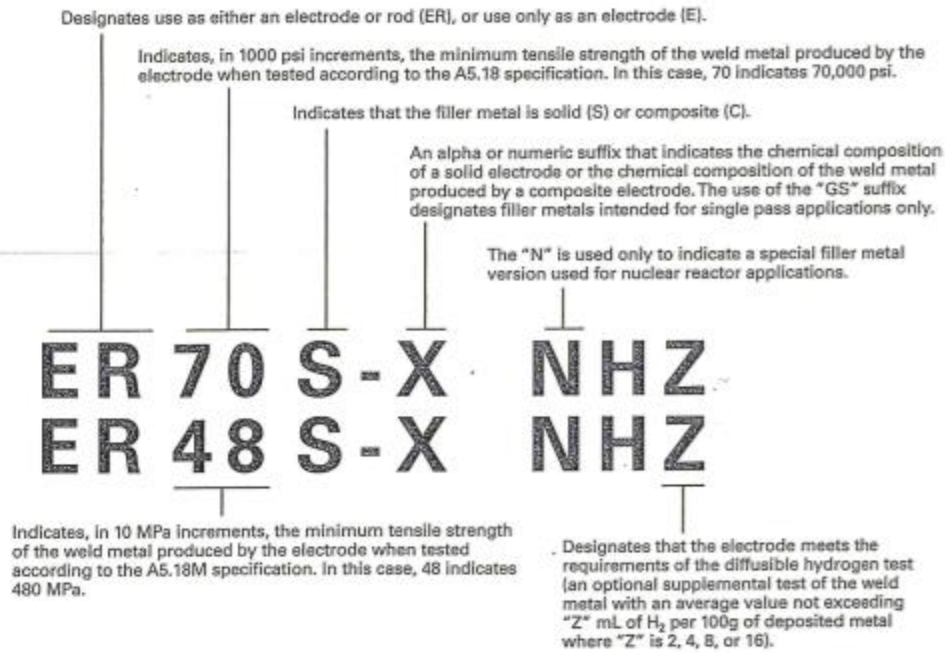


Figure 22 AWS classification for carbon steel filler metals.

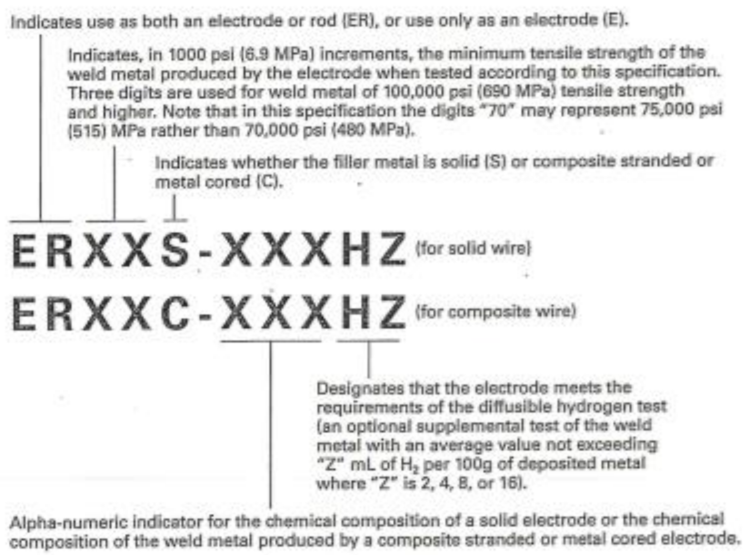


Figure 23 AWS classification for low-alloy steel filler metals.

2.5.2 Stainless Steel Filler Metals

Stainless steel filler metals are identified by *AWS Specification A5.9*. Designations for a typical AWS stainless steel electrode rod classification are shown in *Figure 24*.

Select stainless steel filler metal to closely match the alloy composition of the base metal.

2.5.3 Aluminum and Aluminum-Alloy Filler Metals

Aluminum electrode rods are covered by *AWS Specification A5.10* as shown in *Figure 25*. Aluminum filler metals usually contain magnesium, manganese, zinc, silicon, or copper for increased strength. Corrosion resistance and ease of being welded are also considerations. Aluminum filler metals are designed to weld various types of aluminum and should be selected for compatibility. The most widely used aluminum rods are ER4043 (contains silicon) and ER5356 (contains magnesium).

2.5.4 Copper and Copper Alloy Filler Metals

Copper electrode rods are covered by *AWS Specification A5.7*. Most copper filler metals contain other elements to increase strength, deoxidize the weld metal, and match the base metal composition (*Figure 26*).

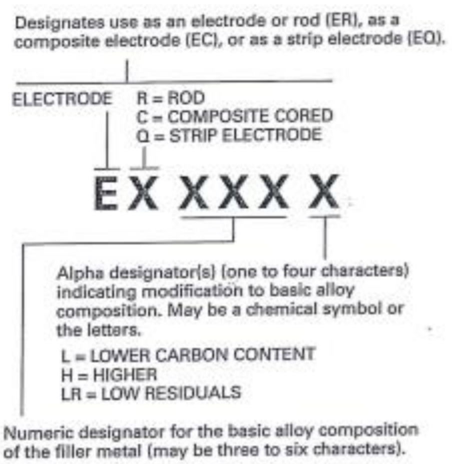


Figure 24 Typical AWS stainless steel rod classification.

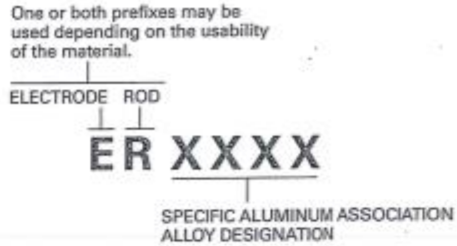


Figure 25 Typical AWS aluminum filler metal classification.

2.5.5 Nickel and Nickel Alloy Filler Metals

Nickel-based filler metals are covered by *AWS Specification A5.14*. These filler metals contain other elements to match base metal applications and to increase the strength and quality of the weld metal. For GTAW, DCEN is used with high-purity argon, helium, or both argon and helium used as a shielding gas. *Figure 27* shows the AWS classification for nickel filler metals.

2.5.6 Magnesium Alloy Filler Metals

Magnesium alloy filler metals (*Figure 28*) are covered by *AWS Specification A5.19*. These filler metals are usually used with GTAW, GMAW, and plasma arc welding (PAW) processes. For GTAW welding, the techniques and equipment are similar to those for aluminum. Argon, helium, or both are used for shielding. Alternating current is preferred for arc cleaning and penetration. Direct current is also employed with DCEP, used for thin materials; and DCEN, used for mechanized welding with helium, for deep penetration. GTAW is recommended for the defect repair of clean magnesium castings.

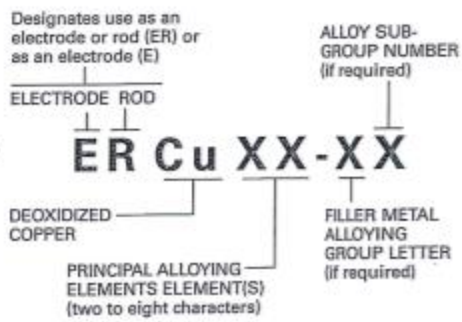


Figure 26 Typical AWS copper filler metal classification.

2.5.7 Titanium and Titanium Alloy Filler Metals

Titanium and titanium alloy filler metals (*Figure 29*) are covered by *AWS Specification A5.16.* These filler metals are generally used with GTAW, GMAW, SAW, and PAW processes. Titanium is sensitive to embrittlement by oxygen, nitrogen, and hydrogen at temperatures above 500°F (260°C). Like aluminum, titanium requires weld cleaning and high-purity gas shielding, and an especially adequate postflow shielding, to avoid embrittlement. Titanium can be successfully fusion-welded to zirconium, tantalum, niobium, and vanadium. Titanium should not be fusion-welded to copper, iron, nickel, or aluminum. Like magnesium, titanium fines are also flammable, so don't allow them to accumulate.

Rod and Electrode Designations

The letter R that follows the E in an AWS classification number indicates that the classification is used as a metal filler rod as well as an electrode. Electrode wire is used in GMAW. Since a tungsten-based electrode is used in GTAW, filler metal classifications with an ER must be used.

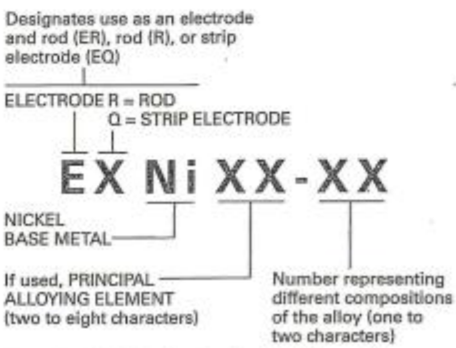


Figure 27 AWS classification for nickel filler metals.

2.5.8 Stainless Steel Flux-Cored Electrodes and Rods

Figure 30 shows the *AWS A5.22* specification format for stainless steel flux-cored electrodes and rods.

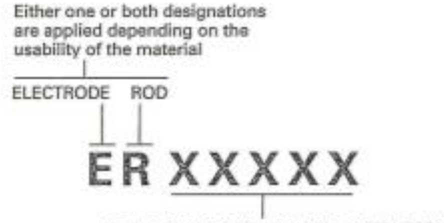


Figure 28 AWS classification for magnesium filler metals.

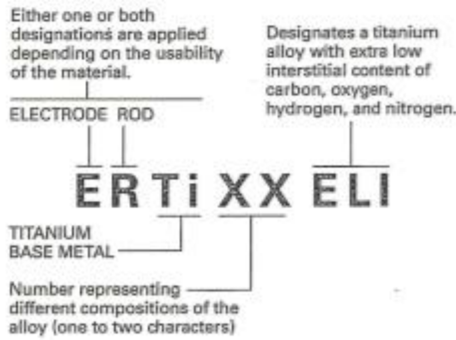


Figure 29 AWS classification for titanium filler metals.

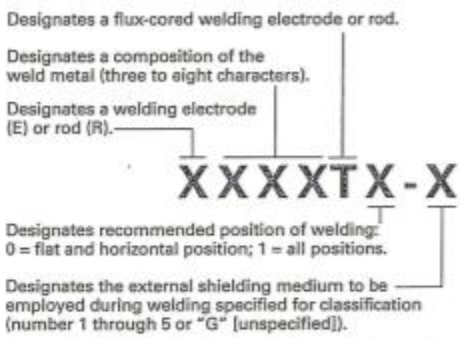


Figure 30 AWS classification for stainless steel flux-cored electrodes and rods.

Magnesium Fires

While ignition of magnesium is a very remote possibility when welding, the fire will cease when the heat source is removed. Ignition of the weld pool is prevented by the gas shielding used in GTAW, GMAW, and PAW processes. Most magnesium fires occur when fines from grinding or filing, or chips from machining, are allowed to accumulate. Take care to prevent the accumulation of fines on clothing. Graphite-based or salt-based powders recommended for extinguishing magnesium fires should be stored in the work area. If large amounts of fines are produced, collect them in a waterwash-type of dust collector designed for use with magnesium. Follow special precautions for the handling of wet magnesium fines.