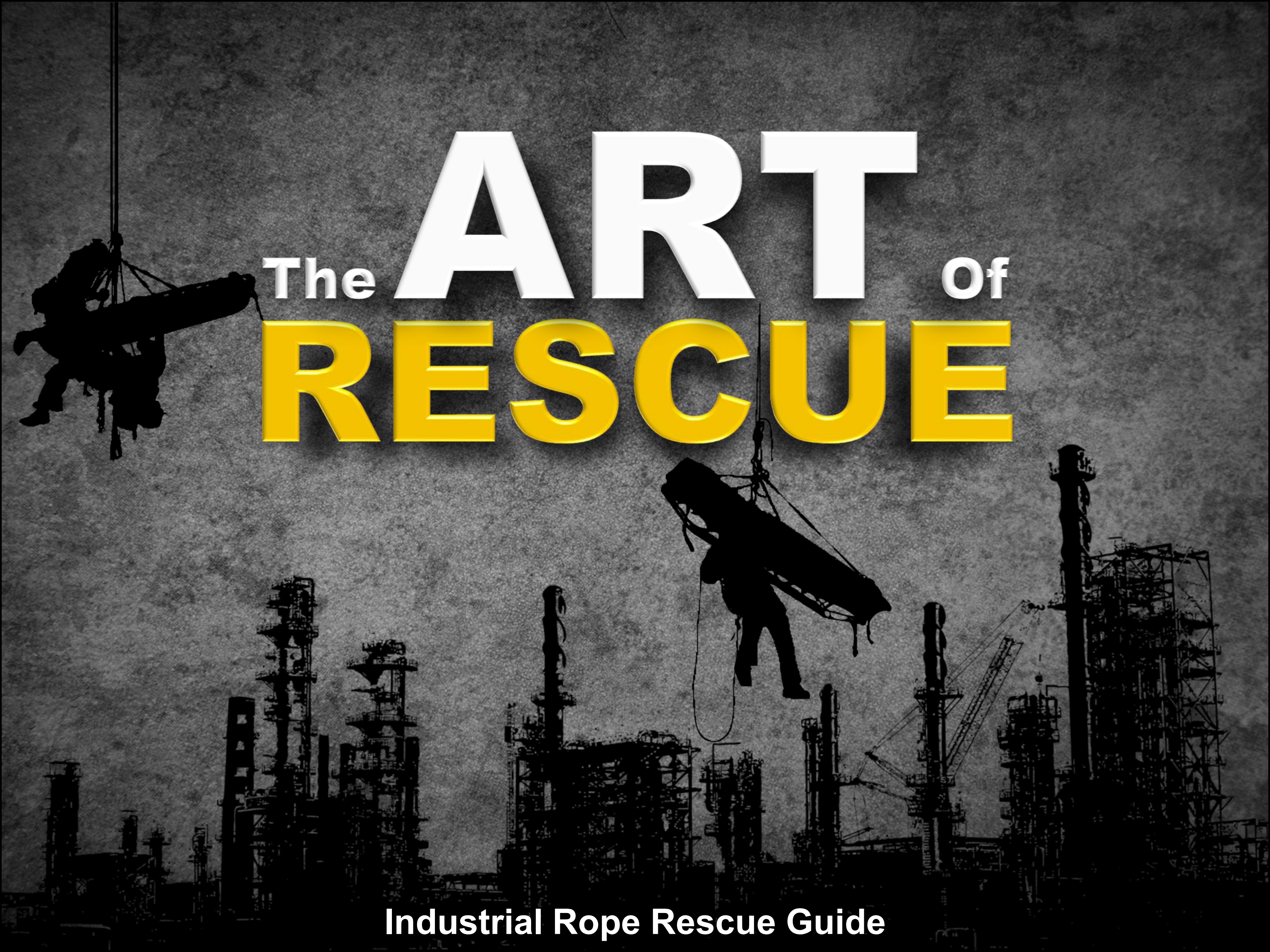
The ART Of
RESCUE
Industrial Rope Rescue Guide

Disclaimer

Rope rescue is inherently dangerous. Even if the techniques, procedures, and illustrations in this material are diligently followed, serious injury and/or death may result. This material makes no claim to be all-inclusive on the subject of rope rescue. There is no substitute for quality training under the guidance of a qualified instructor.

Insofar as the author of this material has no control over the level of expertise of the reader, or the manner this information is used, the author assumes no responsibility for the reader's use of this information.

There is no warranty, either expressed or implied, for the accuracy and/or reliability of the information contained hereof.

Description

This Masterclass presentation for rope rescue has been developed by Shayne Torrans. The focus of this presentation is to deliver a high-quality educational and practical understanding of the basic principles of rescue. The areas of discipline in this material are tailored to the petrochemical and industrial arena, including but not limited to high angle, structural and confined space, but could be applied to virtually any rescue scenario. The opinions and best practices that are delivered in this information are based upon 25-years of experience in the petrochemical industry. There are many other subjects that could be included as areas of discussion, as this material is not all inclusive. Note that questioning and challenging of these topics are not only welcomed but encouraged! It is imperative that the rescuer understand what to do, how to do it and most importantly why they are doing any task associated with rope rescue. Additional materials are available for more specific applications. This program starts with a self-assessment of the rescuers proficiencies in core competencies and then help identifies a customized path for Rescuers' to improve themselves, their knowledge and skills.

How to Use This Guide

Ideally, this presentation could be used as an Operational Field Guide or as a reference for training and practicing.

Certain skills and information in this presentation fall under 1 of 5 categories.

- A   Awareness Level I
- O   Operations Level II
- T   Technician Level III
- S   Specialist Level IV
- IC   Incident Commander V

The colored icons next to the 5-levels indicate the skill and/or information that a rescuer at that level should be able to know and/or perform. These icons will be at the upper right-hand corner of each slide. This indication may not line up exactly with the NFPA 1006 due to a team deployment size of 2-3 people and the added Specialist and Incident Commander Level. This guide does not include all elements of each NFPA 1006 discipline.

External Links

This icon indicates additional online video tutorials:

This icon indicates a manufacturer's user manual or operational procedure:

This Icon indicates an operational checklist:

This icon indicates an information retention quiz:

On certain pages there will be these icons which are web links out of this presentation to desired content. Linked content may require a high speed internet connection.

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Prologue

Prologue

Although there is a certain utility to rescue that is required and fundamental, The Art of Rescue cannot so easily be described, it can only be felt. I'm afraid only rescue passionate people would get the rest of this message anyway.

In standby rescue we are not getting paid for what we do; we are getting paid for what we know. Therefore, we must know it. To know something is quite different than to understand something. When we first learn about technical subject matter, we learn the basic principle of "how" it works, but usually not the "why". To actually understand something takes time; the same as it does to actually understand somebody… You may "know" that person, but do you actually "understand" them?

Most of us know the basic principles of rescue. It is a perishable skill; unfortunately, the more technical it becomes the more perishable it becomes.

The primary issue within the petrochemical industry is the majority of rescuers believe they can perform a technical rescue within the limitations of a 3-man team while in the industrial arena. I personally do not believe this is the case (Statistical data proves otherwise). In conjunction, they also only believe that there are certain requirements in which are needed in order to perform a technical rescue. By not truly understanding the first issue, they cannot even begin to asses nor understand the second, along with everything else that would fall in line after that.

Let me explain*:* **The most critical and overlooked assessment in rescue is to understand the behavior of an outmatched team.**

Think about what that means…

Most rescuers in the industrial sector attend a “Level I” Rescue Class that may have a menagerie of names regardless of where the class was instructed or who instructed it, it may be called:

- Technical
- Structural
- High-Angle
- Confined Space

The class would usually entail basic knots, simple haul systems, primitive lowering systems and fundamentals of packaging. The reason this particular subject matter is taught is due to a NFPA standard in which everyone within the industry holds very high. This practice is generally accepted by fire fighters and of the like whom usually have much larger teams and support systems when deployed in the field.

The 3 fundamental problems:

1. Standard NFPA Level 1 rescue requires 6 rescuers (or more) to perform virtually any standard **team** task.

Example: On a simple Lower System you need a person to operate the Primary, Safety and Tag Line, while 3-sets of hands holding the basket. This does not include additional personnel for adjuncts and/or litter attendants, etc.

2. The current petrochemical industry standard for sending out a 3-man rescue team into the field to execute work.

Reasoning: This is most likely based on a team billable rate divided by inherent risk.

3. The average rescuer in the field does not realize that they are outmatched until an actual incident takes place by 2:1.

Explanation: This is a 50% deficiency by any calculable account. (Simple math explains the basic equation above.) The Rescuers are executing in the field with half of the team that they are a custom to, therefore they must be at least twice as good just to meet the minimum requirements.

I have always been curious to understand the following statistic in everyone's head. Every time I ask a Rescue person if they know the odds against them for entry (which is 66% against) most rescuers never ask why. If they do ask, they never truly understand what the answer means, or they believe the statistics are acceptable and understood. Just know, Everyone Can't be part of the 33%! The majority is part of the 66%. Unfortunately, that is how statistics work. That is 3 people per 10 that can get it done without injury or death.

Example: 1/3 of the people in the room

More interestingly, in my experience it usually is not until a rescuer has about 10 to 15 years in the field until they actually understand that they do not know enough to actually perform on an inefficient team based on team size. For whatever reason that is when they start to really learn and hone their craft. Very few continue with their education earlier than that. If a rescue technician had perused any advancement in training on their own accord earlier than that, it was an anomaly.

Most rescue personnel in the field have only attended a “Level 1” type class and maybe a continuation of that by refresher annually. Rarely do they progress onto other more advanced trainings. Because of this, the industry is stifled by a complete lack of “real” knowledge and experience. This is actually fortunate in one way. Thank God we have a ton of preventative measures in place to keep real rescues from happening on a daily basis in the petrochemical industry. On the other hand, if more of them took place more often, it would change the existing perception within the industry. We are not doing our “Stand-by” rescue teams any justice by not letting them get exposure via experience.

On a different note, understanding the difference between what is someone’s problem and what is someone’s fault is rarely addressed. Someone attempting to identify “whose fault it is” rather than accepting that there is a standard level of training that does not match team requirements and expectations in the field is looking for a scape goat. We have to address that we are all part of the equation.

Training verses practicing:

Initial training is conducted in the classroom, coupled with hands on training and verified by testing. Usually there is:

- General Knowledge test
- Knot Tying test
- Skills Assessment

These tests try to identify the basic coverage requirements of the NFPA, OSHA and/or a company requirement.

The “real” test of a team comes from how well they can perform TOGETHER. The only way a team becomes efficient is by practice. A team MUST practice together and OFTEN! An individual assessment is ideal, and a standard evaluations between teammates are typical. In our industry this is difficult because we have a multitude of teams and members working erratic schedules. The only way an individual team will get better is that the particular team of that day practice.

If a team has difficulty performing because particular individuals do not maintain certain perishable skills, and the team is aware of that fact, it is a problem. We are only as strong as our weakest link! Part of being on a team is the understanding that basic principle.

I often ask team members, "If I were out there with you guys every day for a month, how well do you think we would perform?" the answer is always the same. "That would be amazing!" Why is that? I will tell you…

I would not allow a non-cohesive team! I would not allow for a team to not practice! I would not allow myself or someone else to be a weak link! I would push and push and push for greatness! Not because I am getting paid to do it, not because I was the Team Lead, but because I have enough experience to know if the proverbial shit hits the fan, we MUST perform! I am passionate about what we do, and I want to be surrounded by greatness!

25-years ago people were not even allowed on a rescue team until they had several years of experience. Today with the increasing demand in the field, more and more rescuers are needed to fulfil the demand, it's just not possible.

Younger rescuers are becoming more prevalent in the industry. Unfortunately, we must accept this fact. More importantly we must embrace it! While 5-years of experience would be nice, it is not practical. Even if it were, if someone sat in a truck for "standby" rescue for 5-years and never actually performed a rescue, they would not have 5-years of experience in rescue; they would have 5-years of experience sitting in a truck, which would not do us much good.

I think it is fair to say, we do not know what anyone would do in a real-world scenario until it happened. I could speculate that about 66% of the rescuers would fail statistically speaking!

We all learn and retain information at completely different rates; the only way to equalize this imbalance issue is to practice together. Perform individual races with your team mates on knot tying:

- Critique the Speed
- Critique the Gains
- Critique the Knot Quality
- Critique the Dressing
- Critique the Safety (If applicable)

Do the same thing with Haul Systems, Packaging and Lowering Systems. We do not have to perform evolutions to practice. Vicariously, by practicing, we will teach some, we will learn some. This is important because to evolve, we must be involved! If we want a higher level of technician in the field which leads to a higher quality team, we must teach, learn and practice.

In the field, start with basic knots and Simple Systems. Then move on to more uncommon knots and Compound, Complex and more difficult Systems. Start small, finish big!

As teammates, we need to evaluate every team, every member, every day. We must assess what we have to work with. We need to know what tools we have available. If we need to drive a nail, don't grab a screwdriver, get a hammer; if we are not evaluating by practice we won't even know the difference.

As with anything in technical rescue, proficiency is a must! Rescuers should have the ability to practice and perfect their craft without being mandated certain skills based on assumption. Remember, as Jason Ilowite once said "Technical rescue is not meant to be taught to the lowest common denominator. Rescuers should be critical thinkers capable of learning new skills."

Sincerely,
Shayne R. Torrans

Introduction

Principle

To successfully gain the required skills to effectively and safely rescue an injured or ill victim from various confined spaces and high-angle situations while staying within the limitations of your training and selected equipment.

Objective

At the completion of this material, you will be able to:

- Safely approach, evaluate and access emergencies
- Safely select and use rescue equipment
- Tie rescue knots successfully
- Safely construct anchor systems used for vertical and horizontal applications
- Safely package and transport an injured or ill victim to medical attention
- Successfully select and construct mechanical advantage haul systems used for retrieval of victims
- Select and construct lower systems capable of transporting a rescue sized load
- Descend a fixed rope system

Commitment to Excellence

Philosophy

"He who fails to plan is planning to fail"

- Sir Winston Churchill

YOU MUST LEARN FROM THE MISTAKES OF OTHERS. YOU CAN'T POSSIBLY LIVE LONG ENOUGH TO MAKE THEM ALL YOURSELF.

- SAM LEVENSON -

Mere-Exposure Effect

The mere-exposure effect is a psychological phenomenon by which people tend to develop a preference for things merely because they are familiar with them. In social psychology, this effect is sometimes called the familiarity principle.

This is one of the reasons it is easier to teach new students than students who already have training in a particular subject matter.

Life's Fundamental Truths

- All liquids are fluid, but not all fluids are liquid.
- Things that are hot may glow, not all things that glow are hot.
- Being busy does not equal being productive.
- You're only as good as those you associate with.
- Your team is only as strong as your weakest link.
- Time, not money, is your most valuable asset. Use it to advance your career while you still have it.
- The good news is the sheer act of practicing will help you come out of your shell. The bad news is that you have no other choice if you really want to be amazing at what you do.

Life's Fundamental Truths

- To work tirelessly something you hate is called stress. To work tirelessly for something you love is called passion.
- Doing the same thing over and over again and expecting a different result is insanity
- Being noticed is not the same as being remarkable. Don't get noticed for the wrong reasons. Be remarkable for your smartest and best work.
- Nobody ever complains about what they cannot change. They complain because it is easier.
- You become what you believe.
- When you show up to do your job, regardless of how smart you are, you're going to take your head with you… you might as well fill it with whatever knowledge you can, it won't be one ounce heavier if you do. I would rather have it and not need it than need it and not have it!

The Unfortunate Reality

Technical rescue training must be based on potential, and not on call frequency. It is a total commitment by the individual technician as well as the entire company. Technical rescue training is dangerous; the only thing more dangerous is not training.

If the expectation of our equipment is a 15:1 Safety Factor, then why would we expect anything less of our team. If our team is deployed in the field with half of the team we train with, then they must be twice as good.

15:1 x 2 = 30:1

This is the expectation! Train, Practice and Critique as much as possible to ensure you and your team reach a 30:1 safety margin based on potential risk.

Suggested Training Schedule

Note: Technical rescue disciplines are vast, and this schedule makes no attempt to cover all areas of technical rescue. The following training schedule addresses only vertical rescue and confined space rescue.

Vertical Rescue

Actual training depends on the desired skill level. This is what I would recommend as a minimum yearly, continuing education standard:

Awareness level - Low Angle Evacuation (Less than 40°).

- Rig and operate a tag line on a litter.
- Perform a caterpillar pass.
- Perform proper patient packaging.

4 hour class, 2 times per year.

8 Hours Total

Suggested Training Schedule

Operational level - Steep (40° to 65°) To High Angle (more than 65°) Evacuations.

- Awareness skills. 8 hours
- Personal skills (climbing, rappelling, self-rescue) Two 4hr. classes, 8hrs. total.
- Rigging and operating a basic rescue system (bombproof anchors, mainline, belay line). Two 4hr. classes, 8hrs. total.
- Rig for lower, rig for raise, and convert from a lower to a raise and a raise to a lower. Two 4hr. classes, 8hrs. total.
- Perform simple mid-face pick-offs (team base, and rescuer base, with a non-changing fall line). Four 4hr. classes, 16hrs, total.

48 hours per year.

Suggested Training Schedule

Technician level - High Angle With Multiple Changes In The Fall Line.

- Awareness skills plus, Operational skills. 48 hours total.
- Rigging multi-point anchors. Two 4hr. classes, 8hrs. total.
- Understanding fall factors, understanding ideal and practical mechanical advantage. Two 4hr. classes, 8hrs. total.
- Rig high directionals. Two 4hr. classes, 8hrs. total.
- Rig multiple offsets. Two 4hr. classes, 8hrs. total.

80 hours per year.

Suggested Training Schedule

Rescue Specialist level - Highline Operations, and/or Structural Tower Rescue.

- Operational skills, plus, basic and intermediate skills. 80hrs. total.
- Review highline operations, and structural tower rescue.

Two 8 hour classroom sessions per year, 16hrs. total.

- Advanced anchor rigging.

Two 4hr. classes, 8hrs. total.

- Rig 1, 2, and 4 rope highlines, rig English and Norwegian reeve highlines, horizontal and steep highlines (all one time per year).
- 8hrs. each, total 32hrs.
- 2 simulated structural tower rescues per year. 8hrs. total.

152 hours per year.

Suggested Training Schedule

Incident Commander level

- Awareness Skills, Operations Skills, Technician Skills and Specialist Skills152 hours per year.
- Two 4-Hour classes on IC Systems, NIMS, Rescue Pre-Plans and technical writing.

160 Hours per year

Recommended Pre Requisites

First Aid/CPR/AED Training (8 Hours)

HAZWOPER or General Industry Training (40 Hours)
Including:

- Confined Space Training (4 Hours)
- Respiratory Protection Training (4 Hours)

Note: The prerequisites are highly recommended prior to taking this training course!

Certification Recommendations

Confined Space/High Angle Rescue – Technician Level

First Aid/CPR/AED Training for the Rescuer (8 Hours)

HAZWOPER or General Industry Training or equivalent (40 Hours)

Confined Space & High Angle Rescue Training (80 Hours)

Note: This should be the minimum required training for a 3-man rescue team in the industrial arena preforming confined space rescue.

Safety

Recommended PPE

Rescue Helmet

Corded Ear plugs

Class III Harness

Knee Pads
(If Desired)

Rescue Gloves

Safety Glasses

Safety Boots

Flashlight

Safety Guidelines

Anyone can STOP an evolution for unsafe conditions!

Check and recheck all rigging!

Carabiners must be:

- Locked
- Down
- In

Exercise care with all nylon equipment (Pad where necessary)!

No smoking around software components (Including while wearing Harness)!

Note personal, physical or medical considerations

Note: Make sure everything is safe prior to executing live load operations!

Rescue Priorities

Life Safety is our number one goal

1. Yourself
2. Your Team
3. Patient

Note: We do not trade one life for another!

Rescue Order of Operations

Considerations for rescue from confined spaces should be addressed in the following order:

1. Self Rescue (Preferred)
2. External Rescue
3. Internal Rescue

Note: Only make entry as a last resort!

Redundancy/Interchangeability

When building ANY rescue system it is imperative that the system be backed up!

Remember the NASA Mentality:

1 = None, 2 = One

The concept of backup systems is also known as redundancy. Rescue systems are created in such a way that if one part of the system fails, the system as a whole will still be able to function due to the presence of backup components. Redundancy and backup plans should play an important role in many decision-making processes for the purpose of risk reduction.

Systems as a whole should be constructed with components that have interchangeability as well.

Critical Point Test

This is a test rescue teams use to determine the inherent safety within a rope rescue system.

In order to pass the Critical Point Test, a system must have no point or single piece of equipment which, were it to fail, would cause catastrophic failure of the entire system.

This typically involves finding the weakest link in the system.

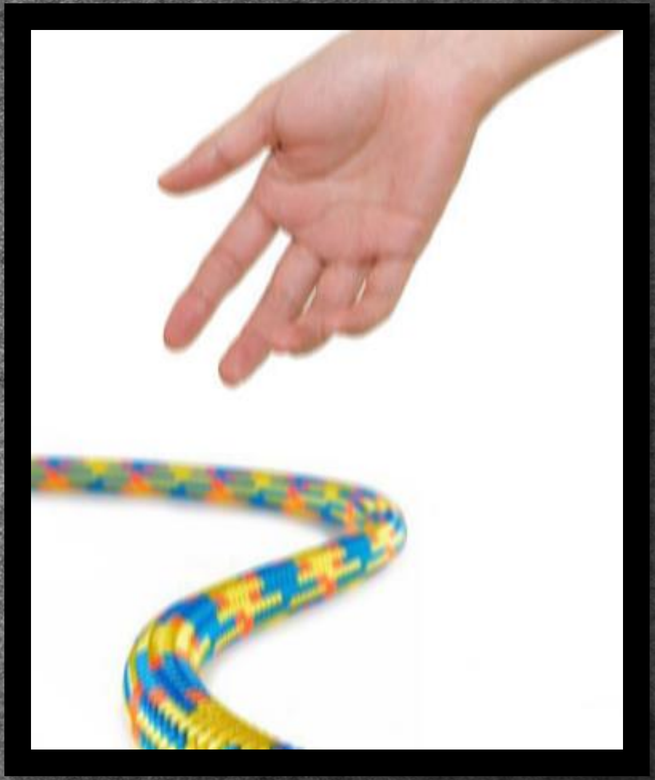
Remember, if its predictable, it is preventable.

Whistle Test

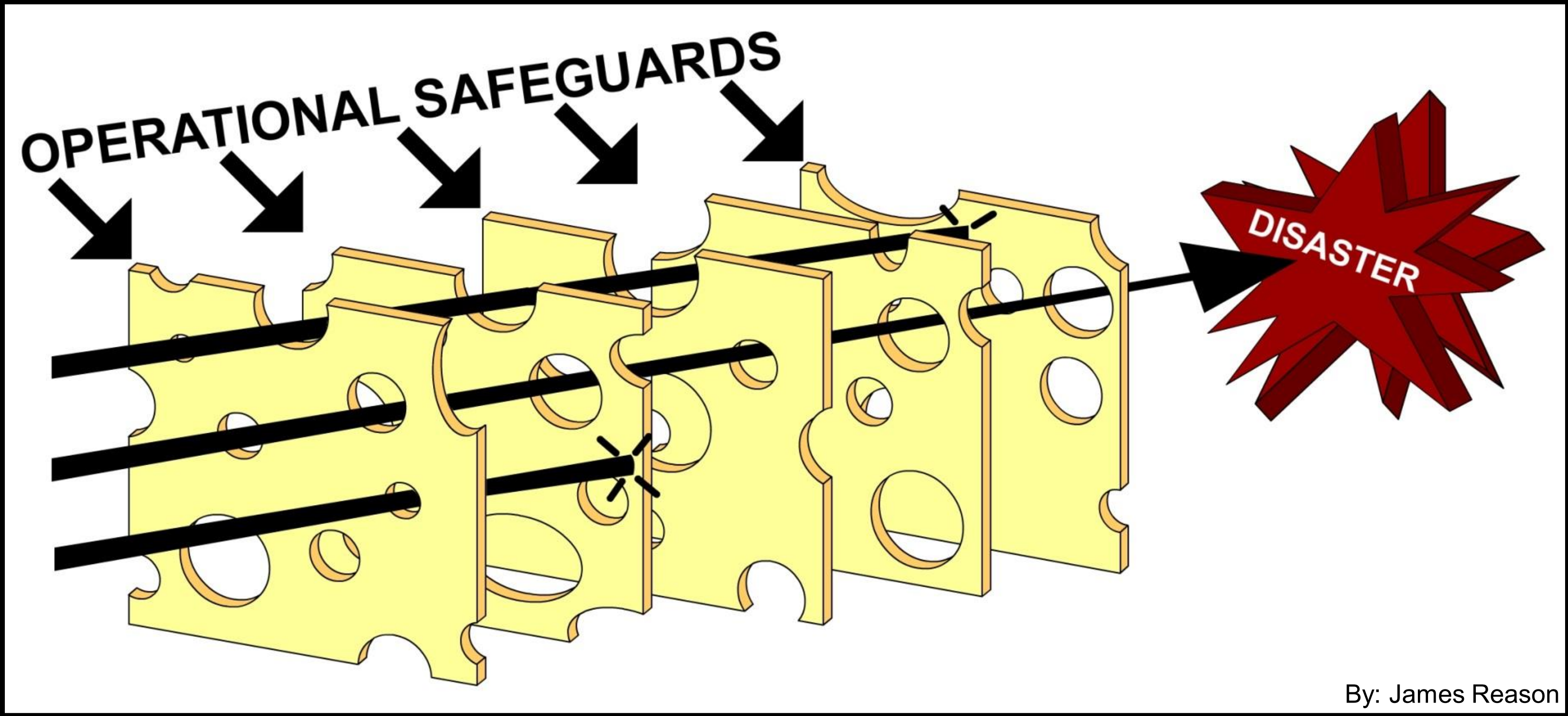
When all rescuers release their ropes, a patient and/or rescue adjunct on the system will not drop or fall.

This safety feature should be built into your main and/or safety line.

- Main Line Options - Petzl ID, MPD, Figure 8 w/Prusik bypass or Brake Bar Rack w/Prusik bypass
- Safety Line Options - Tandem Prusik, 540, Petzl ID, MPD, Figure 8 w/Prusik bypass or Brake Bar Rack w/Prusik bypass



Swiss Cheese Model



The Swiss cheese model of accident causation is a model used in risk analysis and risk management, including safety, healthcare and emergency service organizations, and as the principle behind layered security and redundancy. It is hypothesized that most accidents can be traced to one or more of four failure domains: organizational influences, supervision, preconditions, and specific acts.

Equipment

Software

A flexible fabric component such as:

- ½ inch kernmantle Rope
- 1 or 2 inch Tubular Webbing or Flat Webbing
- 7,8, or 9mm Prusik Accessory Cord
- 2 inch Anchor Straps
- Shock Absorbers
- Lifting Bridles
- Harnesses

Note: Always use caution with software in situations that may cause friction, abrasion and/or cutting.

Safety Factor

10:1 Safety factor	M.B.S. Kilonewton (kN)	M.B.S. Pounds of force (lbf)	Acceptable loads (lbf)
NFPA design load	1.33kN	300lbf	1 Person load
NFPA design load	2.67kN	600lbf	2 Person load
Escape "E"	13.5kN	3,034lbf	303.4lbf
Light Use "L"	20kN	4,496lbf	449.6lbf
General Use "G"	40kN	8,992lbf	899.2lbf

1kN = 225 lbf

Breaking Strengths

Rope or Webbing Size	Minimum Breaking Strength
7mm	2,200lbf
8mm	3,500lbf
9mm	4,500lbf
11mm	7,000lbf
12.5mm	9,000lbf
1” tubular	4,000lbf
1” flat	6,000lbf
2” tubular	7,000lbf

1kN = 225 lbf

Nylon & HTP Characteristics

- Nylon & HTP are synthetic fibers
- Can better absorb sudden shock loads
- More resistant to abrasion
- Nylon does not rot
- Is not damaged by
    - oils
    - gasoline
    - grease
    - marine growth
    - most chemicals other than acids
- Loses considerable strength when wet (approximately 50%).

Nylon & HTP Oppositions

- Never Step on Software (It can grind dirt into it)
- Never put a sharp edge such as a knife to a load (It can cause massive damage to the integrity of the rope)
- Do not get dirty (It can damage the core of the rope)
- Do not get wet (Nylon looses 50% of its strength when wet)
- Do not get oily (Oil attracts dirt)
- Do not get soapy (Soap attracts dirt)
- Keep out of sunlight (Sunlight damages nylon & HTP)
- Avoid Chemical Exposure (Chemicals may reduce the integrity of the material without showing any signs.

Note: More than 10% discoloration may cause need to remove from service!

Static Kernmantle Rope

- Low Stretch 2% at 100lbs – up to 4% during normal use
- Preferred for Rescue
- Resistance to Abrasion
- High Tensile Strength
- High Melting Point
- Not Designed for Shock Loading
- Continuous filament fiber
- Fibers are virgin nylon or (HTP) high-tenacity polyester
- Kern – Core
- Mantle – Sheath (woven cover)

NFPA Performance Requirements

NFPA classifies 3 different rope types

Personal Escape Rope "E"

- M.B.S. 13.5kN (3,034lbf)
- Diameter 7.5mm - 9mm

Light Use "L"

- M.B.S. 20kN (4,496lbf)
- Diameter 9.5mm - 12.5mm

General Use "G"

- M.B.S. 40kN (8,992lbf)
- Diameter 12.5mm - 16mm

Note: All shall have a melting point of no less than 400 degrees.

NFPA Manufacturing Requirements

Life Safety Rope has a continues streamer running through the core of the rope that indicates it meets NFPA 1983 standard, manufacturer, and quarter/year made.

Dynamic Kernmantle Rope

- High Stretch up to 40% at 100lbs – up to 45% during normal use
- Preferred for Climbing
- Resistance to Abrasion
- High Tensile Strength
- High Melting Point
- Ideal for Shock Loading
- Continuous filament fiber
- Fibers are virgin nylon
- Kern – Core
- Mantle – Sheath (woven cover)

Life Safety Rope Rules

These safety rules for any software (such as rope or webbing) will help minimize the reduction of their strength and aid in the safety of the rescuer.

- Do Not Step On The Rope.

  Working on an elevated surface with grating or other sharp edges can damage the rope. Always know where your footing is when working in a high angle environment for your own protection. Ensure not to get tangled up in flaked rope.

- Do Not Straddle The Rope.

  Standing over or too close to a loaded rope exposes you to possible injury if the system fails and the rope snaps back. Standing over an unloaded rope can be painful if the rope is loaded without you knowing it. Never allow anyone to stand in the line of fire of a rope under tension.

- Protect The Rope From Sharp Edges.

  Sharp edges and acute bends can greatly reduce the strength of a rope. Always use edge protection to keep the rope safe from cuts and abrasions, or rig the rope in a different manner.

Rope Care

Inspection

- Hard/Glossy Areas
- Check for consistent diameter/lumps or flat spots in the rope
- Discoloration
- Inconsistent texture or stiffness
- Burns, Cuts, Nicks, Excess Wear on Sheath (Fraying)

Storage Methods

- Coil & Flake
- Rope Bag

Cleaning

- Warm water & Woolite or Sterling Rope Wash agitation/soak
- Rinse thoroughly with rope washer
- Hang Dry

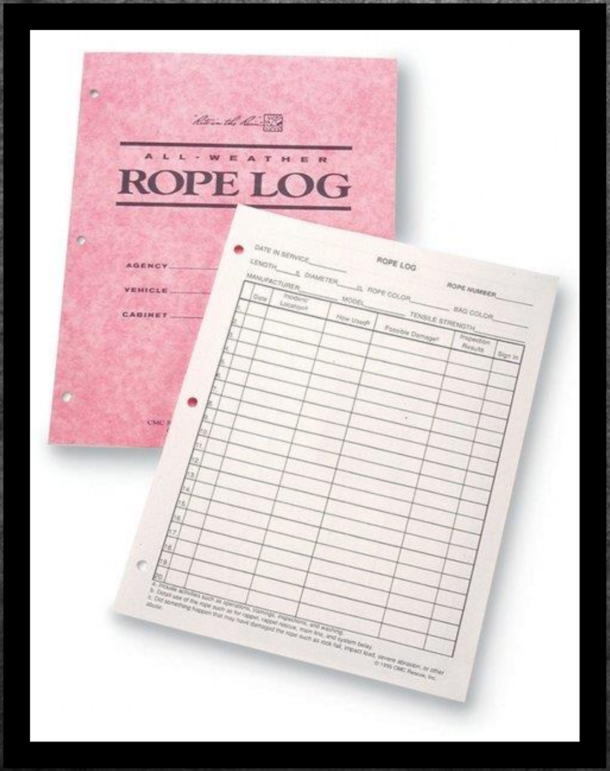
Identification

- Markings on ends of rope & Color

Protection

Rope Logs

- Rope logs document inspection and use
- Logs must be kept together with inspection requirements
- Each rescue rope must be identified and have a specific log sheet



Note: Any shock load or fall on a rope must be noted in the rope log. If a Major shock load or Fall occurs, then rope should be removed from service.

Inspecting Life Safety Rope

The decision to retire a rope or to keep it in service requires good judgement that comes from experience in working with ropes. Inspection is achieved by looking for damage, feeling for damage and checking the ropes history in the log book.

Inspect a new rope prior to putting in service and after each use. This should be done by someone who has been deemed qualified by the organization. Complete inspection includes both visual and tactile inspection.

Check the sheath (mantle, or cover) to identify glazed or hardened surfaces, chaffing, discoloration or variations in diameter. Look for areas of abrasion or cuts where the core (kern) is exposed. If this is the case, the sheath can no longer protect the core. When performing the tactile inspection, ensure the rope is tensioned. Feel for variations in size or hard and soft spots that could indicate damage.

If there are any doubts about the integrity of the rope, destroy it and take it out of service.

Webbing

Tubular Webbing

1 inch = 4,000lbf
2 inch = 7,000lbf

Flat Webbing

1 inch = 6,000lbf

Prusik Cord

- Smaller Diameter low stretch kernmantle rope
- 7mm cord is a great prusik cord for use on flexible 7/16 inch diameter ropes.
- 8mm is the ideal prusik cord size for ½ inch Life Safety Rescue Rope.
- 9mm is a great prusik cord sized for rope greater than ½ inch diameter. Excellent for use in Load Release Hitches as well.
- Typical Knots tied in Prusik cord
  - Prusik Hitch (Triple Wrap)
  - Double Fisherman's Bend

Note: Prusik diameter should be between 50% and 70% of the Host Rope diameter.

Anchor Strap

2 inch Flat Weave nylon Webbing

Multiple Uses

Sewn in “D” Rings

- The stitching is rated for 5,000lbf mil-spec STD858

Pick Off Strap

2 inch Flat Weave nylon Webbing

Multiple Uses

Sewn in “D” Rings

- The stitching is rated for 5,000lbf mil-spec STD858

Load Release Strap

2 inch Flat Weave nylon Webbing

Multiple Uses

Sewn in “D” Rings

- The stitching is rated for 5,000lbf mil-spec STD858

Lifting Bridle

Improvised/Component Bridles
- Rope & Prusik
- Webbing

Pre-Manufactured Bridles
- Purpose Built

Harnesses

Class I

- Designed for emergency escape
- 300lbf. (1.33kN)

Class II

- Designed for rescue load
- 600lbf (2.67kN)

Class III

- Shoulder straps
- Designed for rescue load
- 600lbf (2.67kN)

Shock Absorber

Typically used on the safety line

Sling sewn with stitches that are designed to rip under load so that the impact of the load is gradual rather than sudden. They provide added protection in rescue situations where they not only absorb energy directly because of the stitch ripping effect, but they also allow your rope to absorb more energy from the fall by increasing the time interval of the fall.

Different lengths of deployment

Meets OSHA and ANSI requirements

Yates Screamer/Shorty
Activation: >2kN (450 lbf)
System Peak Loading Reduction 3-4kN
Runner Strength: 26kN (5,850 lbf)

Étrier and Daisy Chain

Étrier (Aider) Typically used as a ladder on the stokes basket for the litter adjunct/attendant

Made of 1-inch (25-mm) mil-spec tubular web and designed specifically for rescue, the etrier is superior for litter tending and other vertical activities. The four steps are stiffened for easier foot entry and abrasion protection. The top hand grip aids balance when moving up or down a tender line. The etrier with Tie-In has a 3-foot (91-cm) multi-loop strap (Daisy Chain) which can be attached to a harness as a safety backup.

Different lengths available. 4 and 5 steps are most common for rescue.

5,000lbf mil-spec STD858

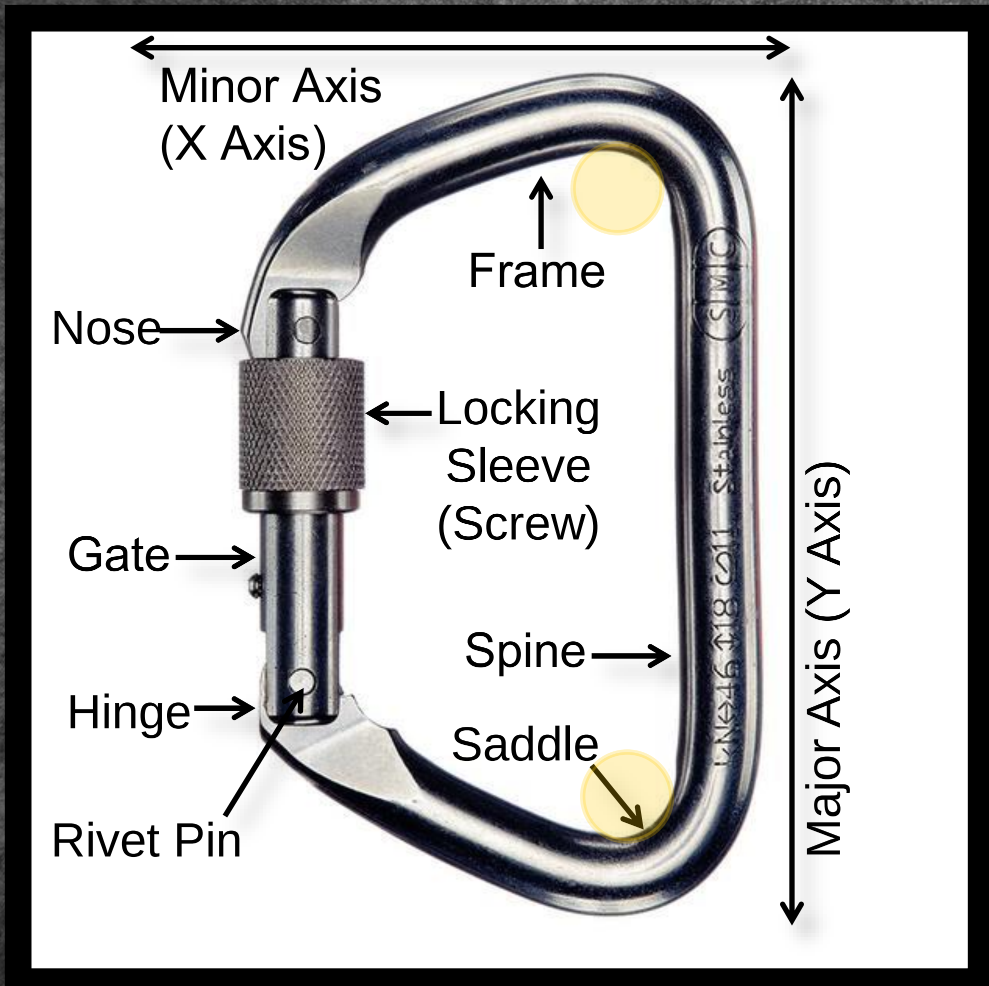
Meets OSHA and ANSI requirements

Hardware

Rigid equipment that includes but is not limited to:

- Carabiners
- Screw Link Connectors
- Descent Control Devices
- Ascent Devices
- Pulleys

Carabiners



General Use Performance Requirements
40 kN (8,992 lbf)

A carabiner is a specialized type of shackle, a metal loop with a spring-loaded gate used to quickly and reversibly connect components, most notably in safety-critical systems.

Carabiners should be orientated Locked, Down & In while in use.

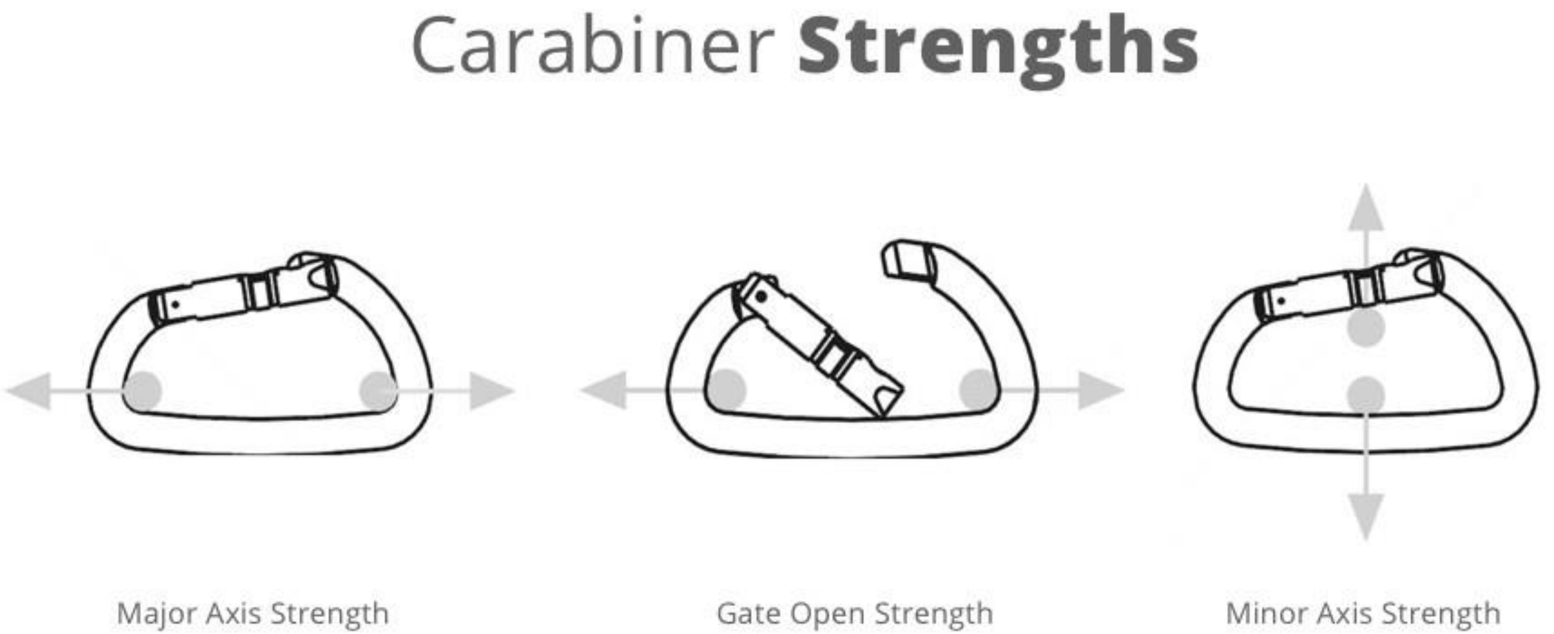
Note: Avoid Side Loading!

Note: No Hard linking!
(connecting 2 carabiners together)

Non-Locking Carabiners

Note: Never use Non-Locking carabiners for rescue operations!

Carabiner Strength



Major Axis Strength	Gate Open Strength	Minor Axis Strength
Light Use	Light Use	Light Use
6,069 lbf (27kN)	1,574(7kN)	1,574(7kN)
General Use	General Use	General Use
8,992lbf (40kN)	2,473lbf (11kN)	2,473lbf (11kN)

Different Carabiner Shapes

A good choice of carabiner shape can increase ergonomics and security for certain applications.

The shape of the carabiner frame has an influence on:

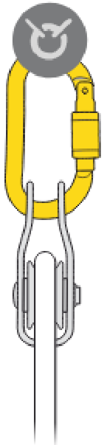
- major axis strength
- load distribution
- gate opening size, and capacity
- strength in certain positions
- ease of handling

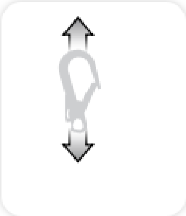
Another less obvious effect is the balance of the carabiner itself: for example pear-shaped carabiners rotate more readily, which can result in poor positioning. D-shaped carabiners tend to stay in place better.

Carabiner Shapes

Oval

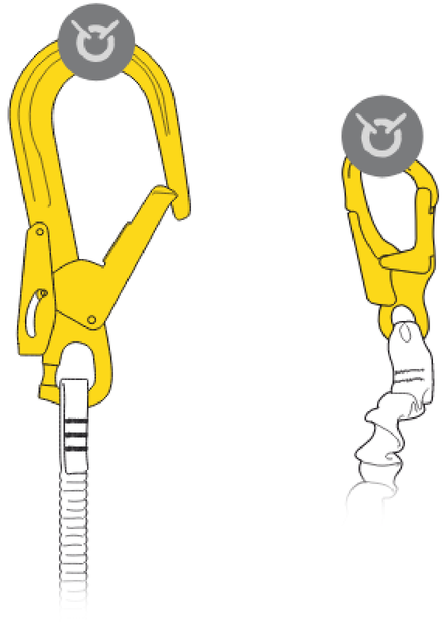
Symmetric shape for even loading (devices with a large attachment hole, pulleys...).





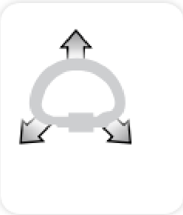
Directional carabiner

Two separate attachment areas to optimize loading on the major axis, for specific uses.



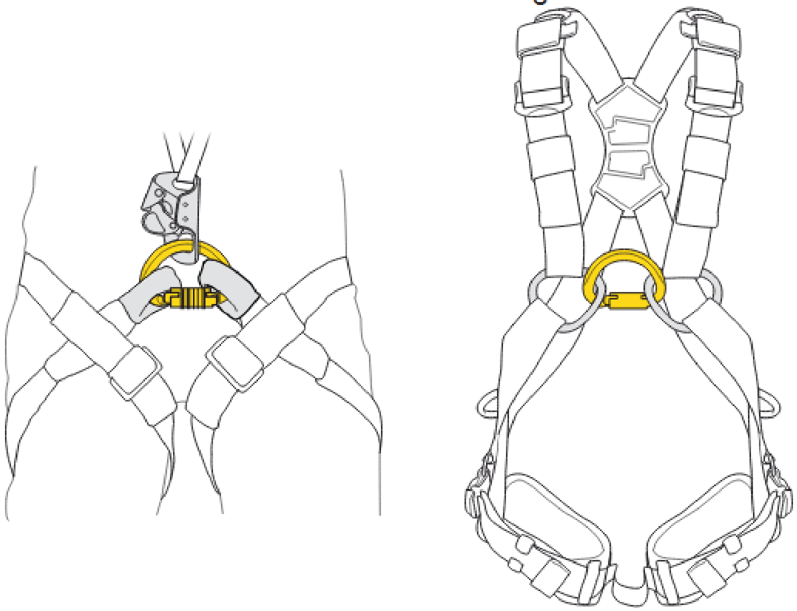
PETZL

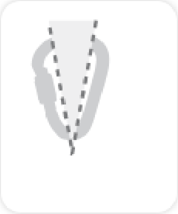
Carabiner Shapes



OMNI multidirectional carabiner

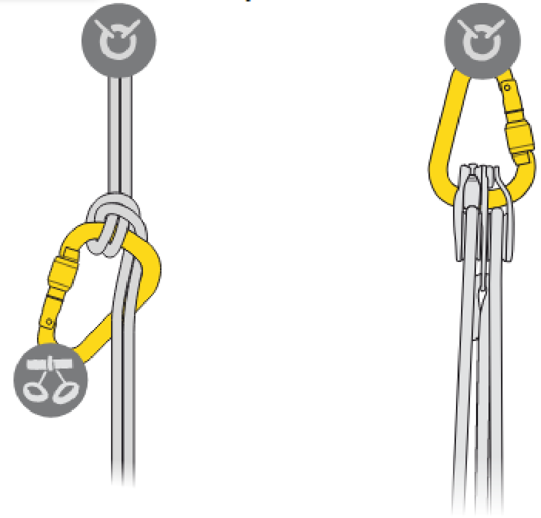
Specific shape suited to multidirectional loading





Pear

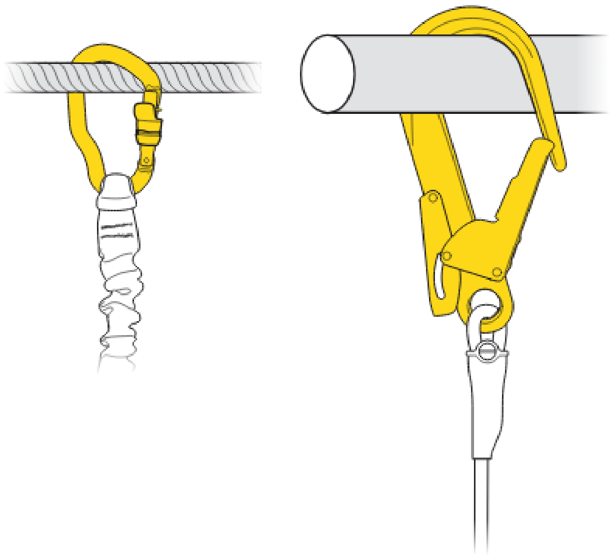
High capacity, for connecting multiple items or bulky items.



Carabiner Shapes

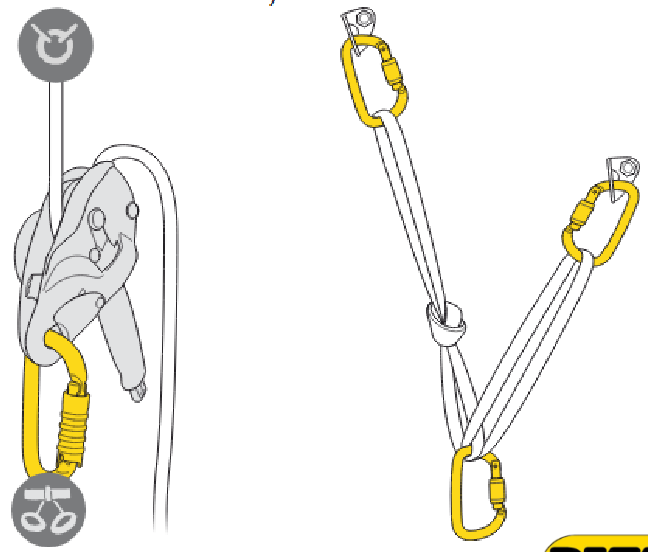
Wide opening carabiner

Wide opening facilitates attachment to anchors, cables...



D

Positioning of the load in the strongest axis, closest to the spine side of the frame. Suited to simple loads (connection of devices, attachment to the anchor...).



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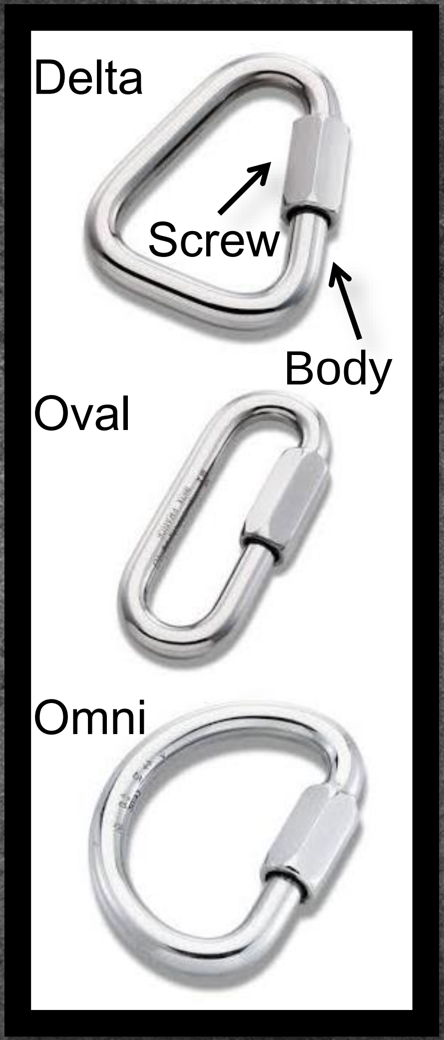
Screw Links

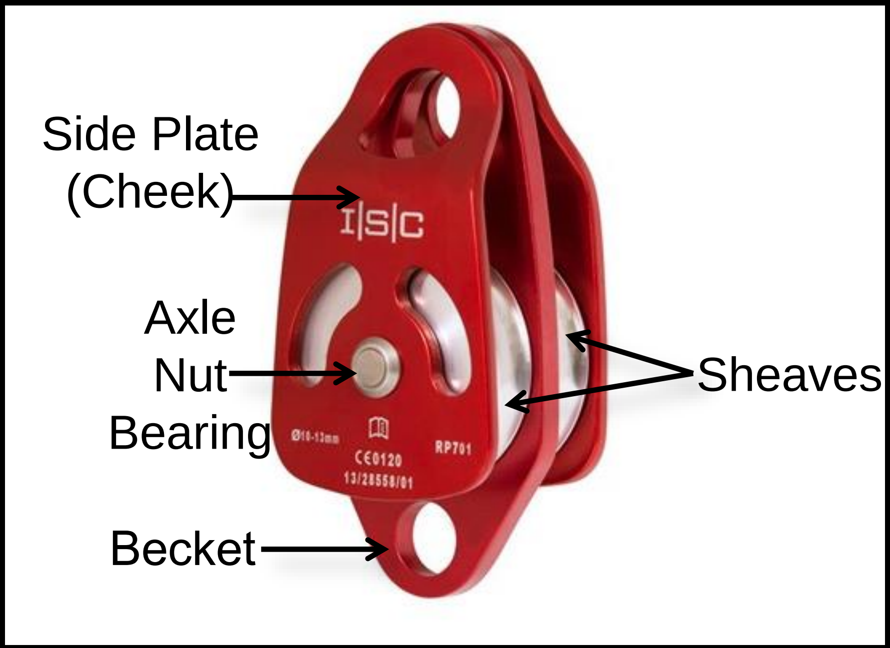


For use in situations for which carabiners are not recommended, such as when tri-axial loading cannot be avoided.

Note: A Delta link can be used anywhere a Carabiner can be used.

General Use Performance Requirements
40 kN (8,992 lbf)

Pulleys



General Use Performance Requirements
36 kN (8,093 lbf)

A mechanical device used to transfer mechanical energy.

It is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut rope.

Note: Sheave tread diameter should be 4x the diameter of the rope

Example: ½ Rope x 4 = 2 inch Sheave

Pulley Types

Kootenay Carriage

Double Prusik Minding

Single Prusik Minding

Omni Block

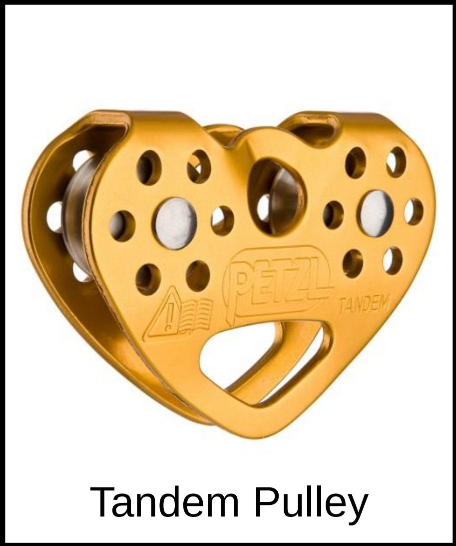
Single Pulley


Knot Passing


Edge Rolling

Pulley Types

Pulleys with Grabs



Tandem Pulley

Triple Sheave

Double Stainless Steel

Single Stainless Steel

MPD

AZTEK Pulley Kit

AZTEK, Inch-worm or Set Of Fours (SOF):

- Personal Mechanical Advantage kit that can be configured as a 5:1 or 4:1 with a re-direct by just rotating the system.
- used as a pick off
- Adjustable directional
- high directional guy line
- high angle attendant tether
- high angle litter scoop
- load release hitch

Each pulley is color coded to match with a corresponding prusik for quick identification.

General Use Performance Requirements
36kN with top Prusik (8,093 lbf)
30kN with bottom Prusik. (6,750 lbf)
18kN when tested only on one sheave, no Prusik. (4,050 lbf)

JAG System

Haul Kit:

- Personal mechanical advantage kit for pickoffs
- Making a releasable anchor
- Tensioning a system

4:1 mechanical advantage and excellent efficiency (sheaves with sealed ball bearings). The collapsed kit is highly compact, allowing it to be used even when the distance to the anchor is very short.

The haul end is color-coded for instant identification.

Technical Use Performance Requirements
MBS 16kN (3,600 lbf) Working Load 6kN (1350 lbf)

Brake Bar Rack

- Aluminum and/or Steel Bars
- Variable Friction
- Will **not** twist the rope
- The first three bars do most of the work
- Used for longer rappels or lowers
- Better for heavier loads
- Industry Standard for Lowering
- Can be “Locked Off”

General Use Performance Requirements
22kN (4,950 lbf)

U Bar Rack

- Aluminum and/or Steel Bars
- Variable Friction
- Will **not** twist the rope
- The first three bars do most of the work
- Used for longer and heavier rappels or lowers
- Better than Brake Bar Rack for heavier loads
- Can be “Locked Off”

General Use Performance Requirements
22kN (4,950 lbf)

CMC 3D

- Aluminum and/or Steel
- Variable Friction
- Will **not** twist the rope
- Used for longer rappels or lowers
- Can be “Locked Off”

General Use Performance Requirements
22kN (4,950 lbf)

Scarab

- Stainless Steel
- Variable Friction
- Will **not** twist the rope
- Used for longer rappels or lowers
- Can be "Locked Off"

General Use Performance Requirements
22kN (4,950 lbf)

Figure 8 with Ears

General Use Performance Requirements
22kN (4,950 lbf)

- Aluminum or Steel
- Available with or without ears. (Ears prevent girth hitch)
- Different sizes
- Will twist the rope
- Difficult to vary the amount of friction applied to the rope
- Should **not** be used if descent is further than 100ft.
- Control is dependent upon the friction against the rappeller’s hip and the squeezing of the brake hand.

Figure 8 (Speed 8)

- Aluminum or Steel
- Different sizes
- Will twist the rope
- Difficult to vary the amount of friction applied to the rope
- Should **not** be used if descent is further than 100ft.
- Control is dependent upon the friction against the rappeller's hip and the squeezing of the brake hand.
- Will Girth Hitch if overloaded

Light Use Performance Requirements
13.5kN (3,038 lbf)

Petzl I.D.

General Use Performance Requirements
22kN (4,950 lbf)

- Allows for variable friction
- Anti-panic function/
- “G” rating
- Accommodates 11.5-13mm rope
- Can be used as an inefficient pulley (25% efficiency)
- Will pass whistle test.

MPD (Multi-Purpose Device)

General Use Performance Requirements
22kN (4,950 lbf)

- Lower & raising capabilities
- Rope-grab mechanism
- "G" rating
- Fewer Components
- Faster Rigging
- Quick Changeovers
- Simplified Training
- Lower Risk
- UL Classified as a pulley, descent control device and belay device
- Will pass whistle test

Traverse 540° Belay

- Lower capabilities
- Fewer Components
- Faster Rigging
- Simplified Training
- Lower Risk
- Will pass whistle test

General Use Performance Requirements
22kN (4,950 lbf)

ATC (Air Traffic Controller)

Light Use Performance Requirements
13.5kN (3,038 lbf)

- Lower capabilities
- Fewer Components
- Faster Rigging
- Simplified Training
- High Risk
- Will **not** pass whistle test
- Single Person Load (300lbs)
- Originally the “Air Traffic Controller by Black Diamond. Every similar device created since gets the “ATC” name by association.

Rigging Plate

- Aluminum or Steel
- Utilizes one anchor point for multiple operations.
- Allows for clean rigging

General Use Performance Requirements
36kN (8,093 lbf)

Rope Grabs

Light Use Performance Requirements
13.5kN (3,038 lbf)

- Aluminum or steel
- Travels and grabs well on wet or muddy ropes
- Spring loaded or free running versions
- Should not be used if there is a potential for a shock load.
- Can damage the rope at high forces

Ascenders

Light Use Performance Requirements
13.5kN (3,038 lbf)

- Aluminum or steel
- Travels and grabs well on wet or muddy ropes
- Spring loaded or free running versions
- Should not be used if there is a potential for a shock load.
- Can damage the rope at high forces

Petzl ASAP & ASAP'sorber

Mobile fall arrester with locking function (If Applicable)

Designed to facilitate handling during rope ascents. In normal use, the device moves freely along the rope without any manual intervention and follows the user in all his/her movements. In case of shock or sudden movement, the fall arrester locks on the rope and stops the user. ASAP Lock has integrated locking function allows the user to immobilize the device in order to reduce the potential fall distance.

Technical Use Performance Requirements
13.5kN (3,038 lbf)
General Use when used with ASAP'sorber on Static Rope

Swivel

General Use Performance Requirements
36kN (8,093 lbf)

- Keeps rescue systems from binding
- Minimizes rope to rope friction on mechanical advantage systems
- Allows for wide range of movement for rescue package

Load Cell

General Use Performance Requirements
36kN (8,093 lbf)

- Facilitates "in-line" use in rigging systems
- Swivel attachment points diminish potentially dangerous torsional and off-axis forces
- Features two sampling modes. "Slow" for monitoring and "Fast" for drop-testing
- Record and download graphs of events (Enforcer app required. Sold separately.)
- Measures force in kg, lbf, and kN
- Max Reading: 20kN
- Accuracy: 2%
- Length: 8.0" (203mm)

Knot Craft

General Information

"In the world of rope rescue, tying a knot speaks volumes. It can tell me immediately how competent the rescuer is."

- Pat Rhodes

Knots, Bends & Hitches

Knot: a fastening made by tying a piece of rope, webbing, or something similar in a prescribed way.

Hitch: A configuration of bights, loops and round turns where rope is tied around an object, and when the object is removed, the configuration will fall apart.

Bend: A bend is a knot used to join two lengths of rope.

Fast rule: A knot ties a loop in a rope, a Hitch is tied around an object, A bend ties ends together.

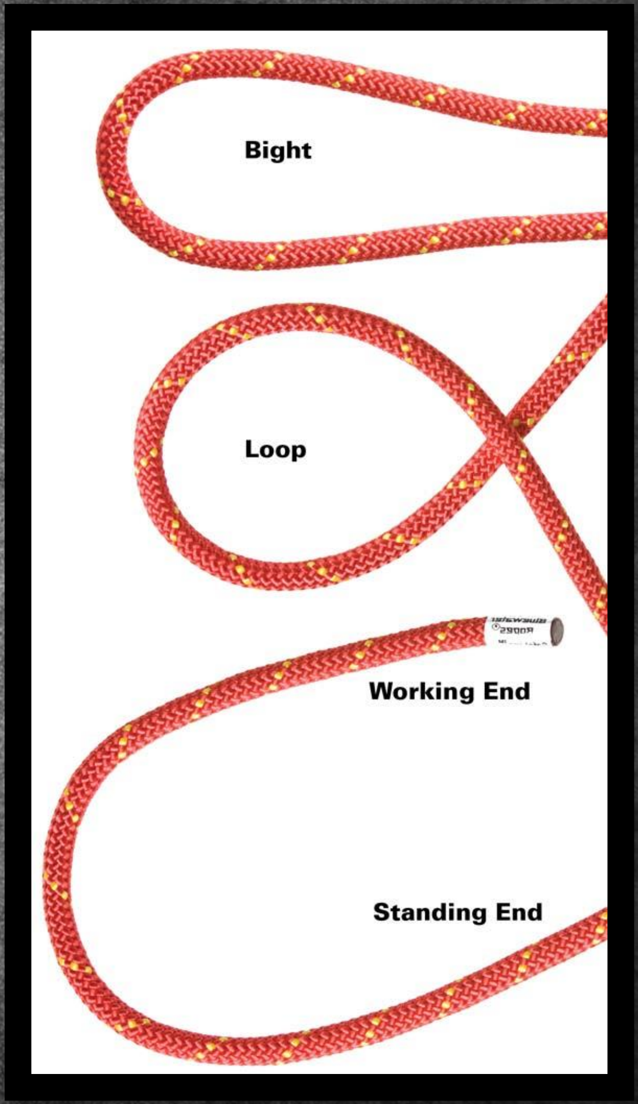
Knot Craft Terminology

Terminology

- Working end
- Standing end (Bag end)
- Bight
- Loop
- Round turn

Characteristics of a Good Rescue Knot

- Easily Recognizable
- Very Strong
- Task Appropriate
- Easy to Tie
- Easy to Untie
- Has a Safety (If Required)



4:1 Rule

4:1 rule refers to the efficiency of rope during bending. If a rope is bent around an object at least four (4) times its diameter, there will be no loss of efficiency due to bending. The "tightness of the bends" determines the efficiency ratings of knots. **Note:** Most rescue knots have a 20-to-28% efficiency loss.

Example: To prevent efficiency loss with ½ inch rope, the knot must have no bends smaller than 2-inches. Anything less than 4 times the diameter is considered an **acute bend**.

Although not possible when tying most knots, this rule must be followed as much as possible (ropes over square edges, ropes through pulleys, etc.)

Important: In order to maintain maximum efficiency (strength) of ropes and rope systems, avoid acute bends! The sharper the bend, the greater the efficiency loss.

Knot Efficiency

When a knot is tied in a rope, it causes a weak point at the knot due to excessive bending. This weak point is called attrition (Loss). A Knot will either:

Creep first and then **Slip** if enough tension is applied

or

Capsize

or

Spill

or

Break

The strength of the rope left is called efficiency, this is what we look for in Rescue knots. We want **Low Attrition** and **High Efficiency.**

Example: ½" Kernmantle Rope = MBS 9,000lbf (End to End)

Figure 8 on a bight = 80% Efficiency

9,000 x 80% = 7,200lbf (½" Kernmantle rope will break at 7,200lbf if a Figure 8 on a bight is tied. It will most likely break at the knot.)

Knot Failure Terminology

Creep: When a hitch is tied around another (Primary) rope or object and begins to travel the distance of the hitch due to tension. This happens prior to slipping.

Slip (Slide): when enough tension is applied to a hitch to allow it to travel further than the width of the hitch, usually resulting in some type of (Primary) failure. In knots that are meant to grip other objects, failure can be defined as the knot moving relative to the gripped object. While the knot itself does not fail, it ceases to perform the desired function.

Capsize: A knot that has capsized has deformed into a different structure. This happens when the knot rolls over itself. When the load creates tension that pulls the rope back through the knot in the direction of the load. If this continues far enough, the working end passes into the knot and the knot unravels and fails. A reef knot, when misused as a bend, can capsize dangerously.

Knot Failure Terminology

Spill: Constant strain and slack can cause ropes to untie themselves.

Break: Knots weaken the rope in which they are made. When knotted rope is strained to its breaking point, it almost always fails at the knot or close to it, unless the rope is defective or damaged elsewhere. The bending, crushing, and chafing forces that hold a knot in place also unevenly stress rope fibers and ultimately lead to a reduction in strength. The exact mechanisms that cause the weakening and failure are complex. Relative knot strength, also called knot efficiency, is the breaking strength of a knotted rope in proportion to the breaking strength of the rope without the knot.

Rescue Knots

Overhand (Simple) Family:

- Overhand (Safety)
- Double Overhand (Stopper)
- Scaffold Knot (Poacher's)
- Water Knot
- Flat Overhand (EDK)
- Overhand on a Bight
- Double Overhand on a Bight
- Overhand Follow Through
- Double Fisherman's Bend

Figure 8 Family:

- Figure 8 (Stopper)
- Figure 8 on a Bight
- Figure 8 Follow Through
- Double Figure 8 on a Bight
- Figure 8 on a Bend
- Directional 8 (In-Line 8)

Bowline Family:

- Bowline (Inside)
- Bowline with Yosemite Finish
- Doubled Long Tail Bowline
- Double Bowline
- Water Bowline
- Bowline on a Bight
- Triple Bowline
- Double Bowline on a Bight

Rescue Knots Continued

Butterfly Family:

- Butterfly
- Double Butterfly
- Threaded Butterfly
- Butterfly on a Bend
- Butterfly on a Bight
- Double Butterfly on a Bight

Reef Family:

- Square Knot
- Surgeon's Knot
- Sheet Bend
- Double Sheet Bend

Hitches:

- Tensionless Hitch
- Girth Hitch
- Double Girth Hitch
- Clove Hitch
- Prusik Hitch (Triple Wrap)
- Asymmetrical Prusik Hitch (3-on-2)
- Purcell Prusik Hitch
- Munter Hitch
- Super Munter Hitch
- Handcuffs (Wristlets) Hitch
- Mariner's Hitch
- Load Releasing Hitch
- Daisy Chain
- Lobster Tail

Knot Tying

While there are many knots available to rescuers, master a few knots that are applicable for most situations. The following knots represent a "good cross section" of the most popular rescue knots.

Remember… Practice, Practice, Practice!

Steps in Knot Tying

1. **Tie:** Tie the knot systematically and uniform every time.
2. **Dress:** Keep the ropes free of twists, legs running side-by-side.
3. **Load:** Once tied, the knot should be pulled tight (in the direction it will load) to avoid any accidental movement when line is loaded.
4. **Safety:** Refers to securing any loose ends. If knot has a loose end (tail), it should be secured using a safety knot if applicable.
5. **Practice:** Most important concept in tying knots… Practice!

Overhand Knot

Used as a backup to secure other knots (Safety Knot)

A Safety Knot used to Secure Loose Ends

Load the Knot as Close to the Primary knot as possible

Efficiency ≈ 50% (end to end)

Reduces primary knot slippage by 50%

Double Overhand Knot

Used to close out the open-end of a “System”

Could replace a Simple Figure 8 as a “Stopper Knot”

Efficiency ≈ 50% (end to end)

Reduces Open Ended System Catastrophic Failure by 100% unless a knot passing pulley or Kootenay Carriage is used.

Scaffold Knot

Used to "bunk" a haul system in the becket of a pulley or on a rigging plate

Used to tie a Carabiner that could be inadvertently side loaded (Choke)

Does not require a safety

Efficiency ≈ 81% (7,290lbf)

Simple on a Bight

Overhand Loop

Used to tie a loop in the end of Tubular webbing

In rope, this knot is most commonly mistied as a figure 8 on a bight.

Efficiency ≈ 65% (2,600lbf)

Double Simple on a Bight

Doubled Overhand Loop

Used to tie 2 loop (legs) in the end of Tubular webbing

In rope, this knot is most commonly mistied as a double figure 8 on a bight.

Efficiency ≈ 65% (2,600lbf)

Water Knot

Ring Bend (Rope), Tape Knot

The preferred methodology for tying the ends of webbing together

Should have a safety knot on both ends

Efficiency ≈ 64% (assuming 4,000lbf MBS)

Tubular Webbing

Tied in a Loop = 5,120lbf

Basket Hitch = 9,943lbf

Wrap 3 Pull 2 = 9,167lbf

Flat Overhand - EDK

European Death Knot, EDK or Flat Overhand

A quick methodology for tying the ends of rope together that will roll over an edge (Edge Rolling Knot)

Should have an additional EDK as a safety knot

Efficiency ≈ 59% (5,310lbf) If not tied properly can capsize at approximately 1,000lbf

Double Fisherman's Bend

The preferred methodology for tying Prusik cord (8mm) together

Used to tie the ends of 2 ropes together, or making endless slings

Does not require a safety

Need 2 inches of tail on ½ inch rope

Needs knuckle of tail on 8mm

Efficiency ≈ 79% (5,530lbf on 8mm)
(14,220lbf on ½" Rope)

Simple Figure 8 (Stopper)

Stopper – used to keep a rope from traveling through a piece of equipment such as a pulley.

Used to close out a system

Foundation knot for 8 on bend or follow-through

Efficiency ≈ 50% (end to end)

Reduces rope running by 50%

Figure 8 on a Bight

Ties a loop at the end of a rope for clipping (Single person, Traveling Anchor)

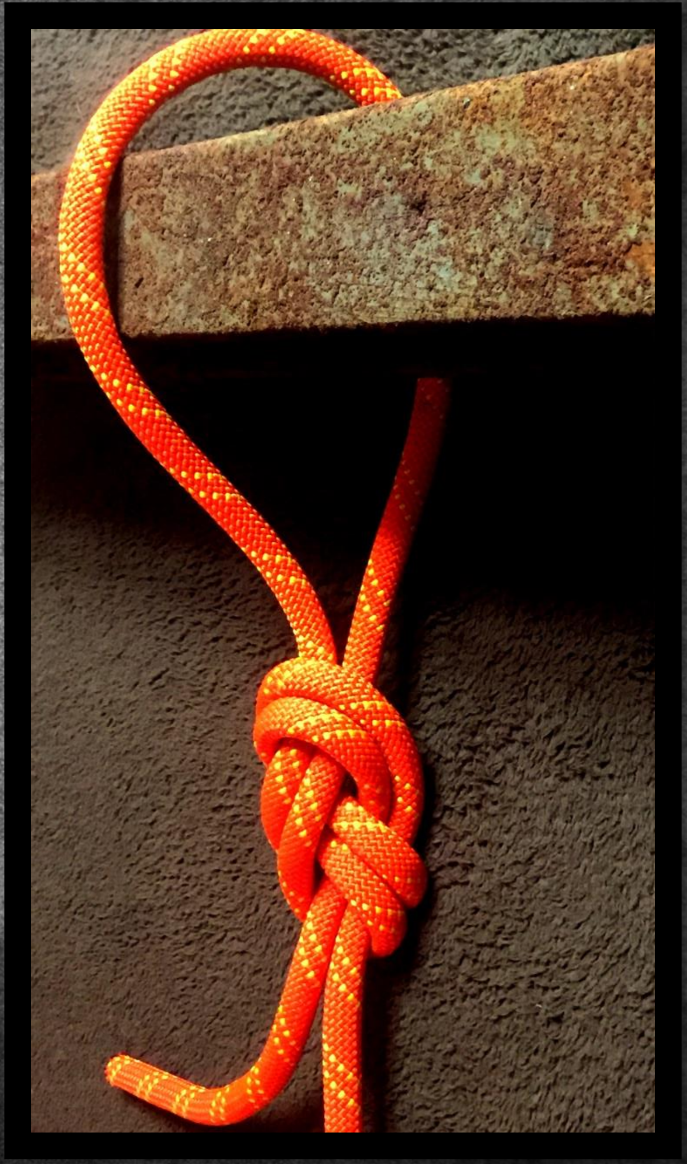
One of the most utilized rescue knots

Efficiency ≈ 80% (Loop to End)
(7,200lbf in ½ inch rope)

Figure 8 Follow Through

Form a secure loop around a fixed object

Efficiency ≈ 80% (Loop to End)
(7,200lbf in ½ inch rope)



Double Figure 8 on a Bight

Ties a loop at the end of a rope for clipping (Two person, Traveling Anchor)

Our Primary Knot for lowering

Efficiency ≈ 82% (Loop to End) (7,380lbf)

Figure 8 on a Bend

The preferred methodology to tie the ends of 2 ½-inch kernmantle ropes together

Efficiency ≈ 81% (7,290lbf)

Directional 8

Used to tie a secure loop in the middle of a rope when the ends are not free (Single Person, Traveling Anchor)

Used for a midline directional pull on a rope

Efficiency ≈ 73% (Loop to End) (6,570lbf)

Efficiency ≈ 51% (End to End) (4,590lbf)

Figure 9 on a Bight

Ties a loop at the end of a rope for clipping or anchor masterpoints (Single person, Traveling Anchor)

Efficiency ≈ 84% (Loop to End)
(7,560lbf in ½ inch rope)

Bowline Knot

Used to tie a loop around something (Single Person, Static Anchor)

Forms a secure loop in the end of a piece of rope

Primary knot used on tag lines

Must have a safety knot

Efficiency ≈ 73% (6,570lbf)

Bowline with Yosemite Finish

This is the preferred methodology for the "Safety" of the Inside or "French" Bowline

This removes the "Safety" from the Gain of the knot.

This would keep the "Safety" from inadvertently getting untied due to being in the way.

Efficiency ≈ 73% (6,570lbf)

Doubled Long Tail Bowline

Used in creating the yoke at the rescue end of the main line and the belay line. The yoke is the point of attachment for the rescue adjunct and litter attachment, and/or “team based pick-off” rescue package attachment.

The doubled bowline is the adjunct attachment point, and the long tails are secondary attachment points for the rescuer and victim. The long tails may be tied to accommodate the type of adjunct used.

Efficiency ≈ 73% (13,140lbf)

Both Ropes

Double Bowline Knot

Used to tie a loop around something (Single Person, Traveling Anchor)

Forms a secure loop in the end of a piece of rope. This knot can be used interchangeably with a Figure 8 on a Bight, but unties easier if loaded.

Must have a safety knot

Efficiency ≈ 73% (6,570lbf)

Water Bowline Knot

The preferred method to tie a loop around something in wet or moisturous conditions (Single Person, Static Anchor)

Forms a secure loop in the end of a piece of rope when wet

Must have a safety knot

Efficiency ≈ 73% (6,570lbf)

Bowline on a Bight

Used to tie 2 loops around something (Single Person, Static Anchor)

Forms two secure loops in the end of a piece of rope

Efficiency ≈ 75% (6,750lbf)

Triple Bowline

Double Bowline on a Bight

Used to tie multipoint anchors and Masterpoints. Fractionates load to multi loops for displacement.

Forms three secure loops in the end of a piece of rope

Efficiency ≈ 75% (6,750lbf)

Portuguese Bowline

The Portuguese bowline is a variant of the bowline with two loops. The two loops are adjustable in size (unlike the Spanish bowline). Rope can be pulled from one loop into the other one even after tightening.

Efficiency ≈ 75% (6,750lbf)

Butterfly Knot

Used to tie a secure loop in the middle of a rope when the ends are not free (Single Person, Traveling Anchor)

Accommodates a load in any direction

Efficiency ≈ 77% (Loop to End) (6,930lbf)

Efficiency ≈ 66% (End to End) (5,940lbf)

Double Butterfly Knot

Used to tie 2 secure loops in the middle of a rope when the ends are not free (Two Person, Traveling Anchor)

Accommodates multiple loads in multiple directions

Efficiency ≈ 77% (Loop to End) (6,930lbf)

Efficiency ≈ 66% (End to End) (5,940lbf)

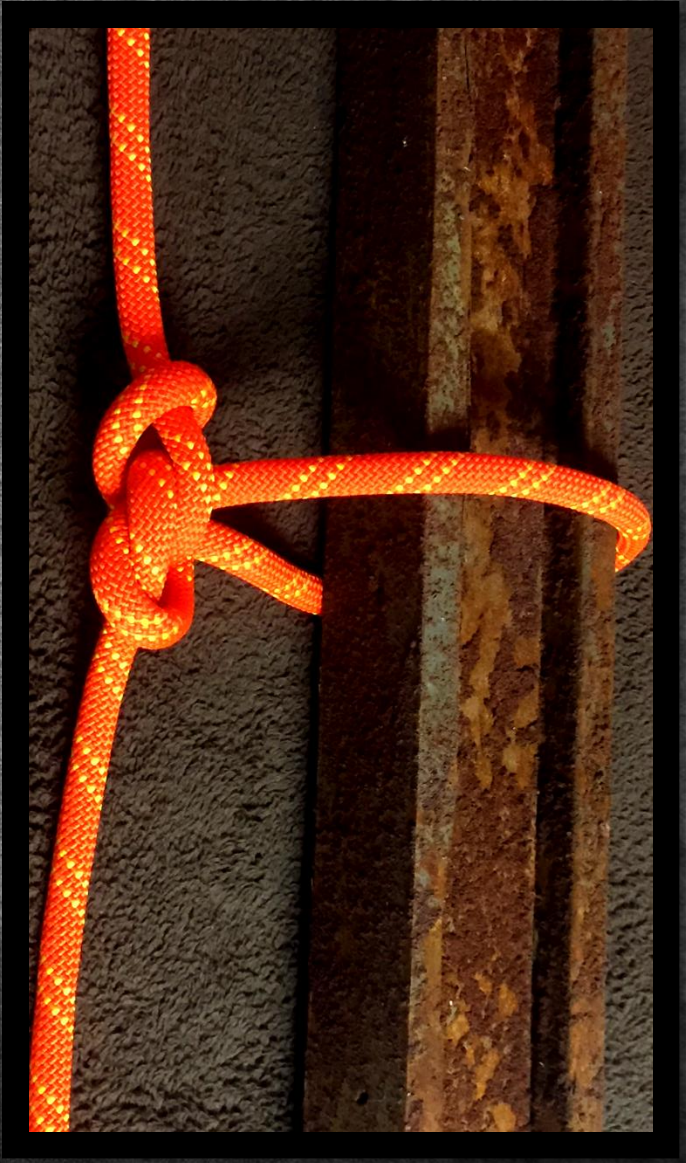
Butterfly Follow Through

Used to tie a secure loop in the middle of a rope around something when one end is free (Single Person, Traveling Anchor)

Accommodates a load in any direction

Gives 2 working ends of the rope

Efficiency ≈ 77% (Loop to End) (6,930lbf)
Efficiency ≈ 66% (End to End) (5,940lbf)

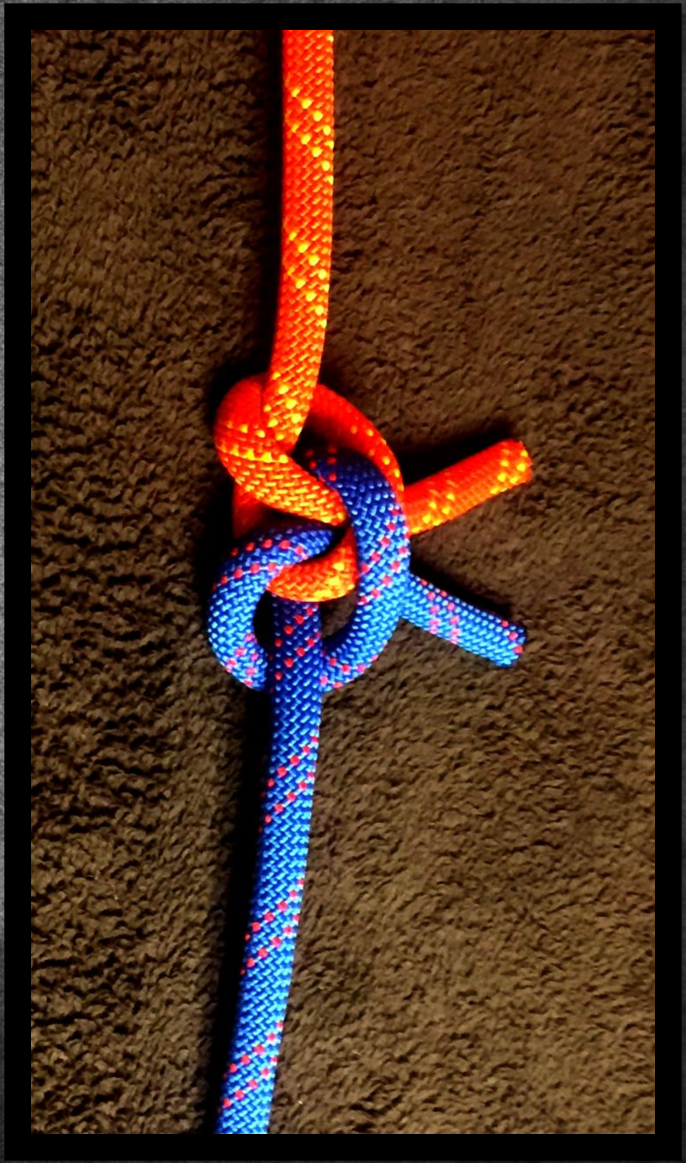


Butterfly on a Bend

Used to tie the ends of two ropes together that will roll over an edge. Asymmetrical Edge Rolling Knot

Accommodates a load in any direction

Efficiency ≈ 66% (End to End) (5,940lbf)
Will not capsize when over loaded



Butterfly on a Bight

Used as a small "soft" rigging plate to help tender a load or to create multiple tie in points.

The Large loop at the top can be wrapped around an object or Anchor prior to tying.

Accommodates a load in any direction

Efficiency ≈ 77% (Loop(s) to End) (6,930lbf)

Double Butterfly on a Bight

Used as a larger "soft" rigging plate to help tender a load or to create multiple tie in points.

The Large loop at the top can be wrapped around an object or Anchor prior to tying.

Accommodates a load in any direction

Efficiency ≈ 77% (Loop(s) to End) (6,930lbf)

Square Knot

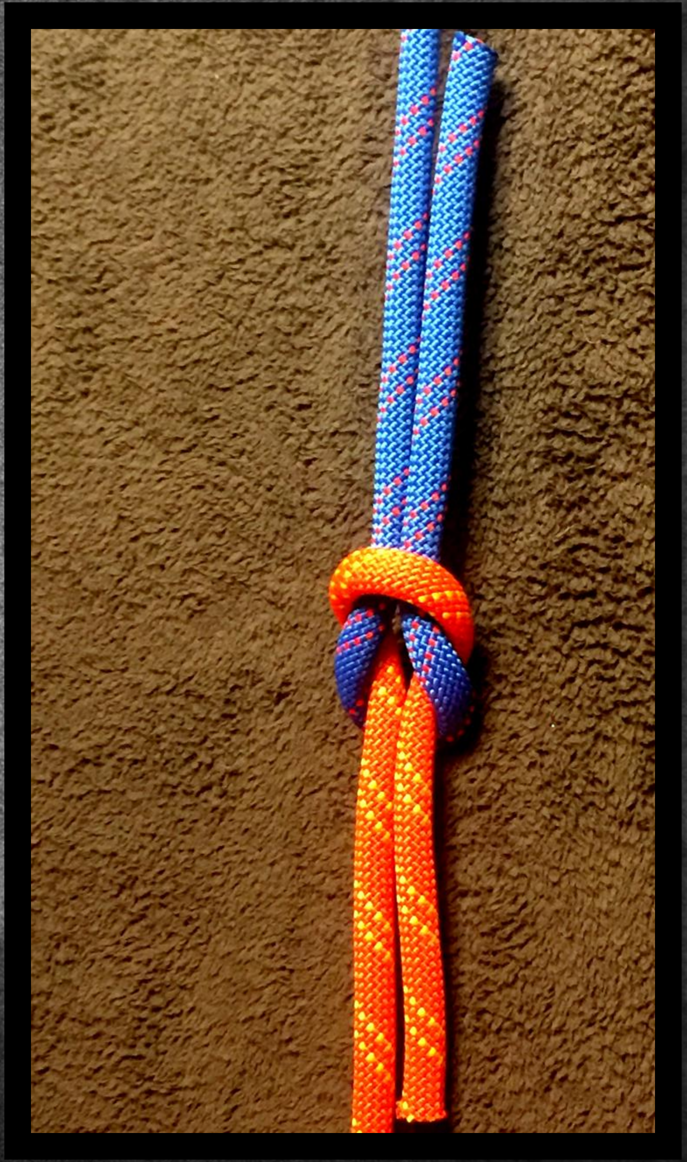
Utility knot

Use with webbing harness

Used to tie 2 ropes of equal diameter together

Both tails must have "safety"

Efficiency ≈ 50% (4,500lbf Rope)
Efficiency ≈ 35% (2,600lbf Webbing)



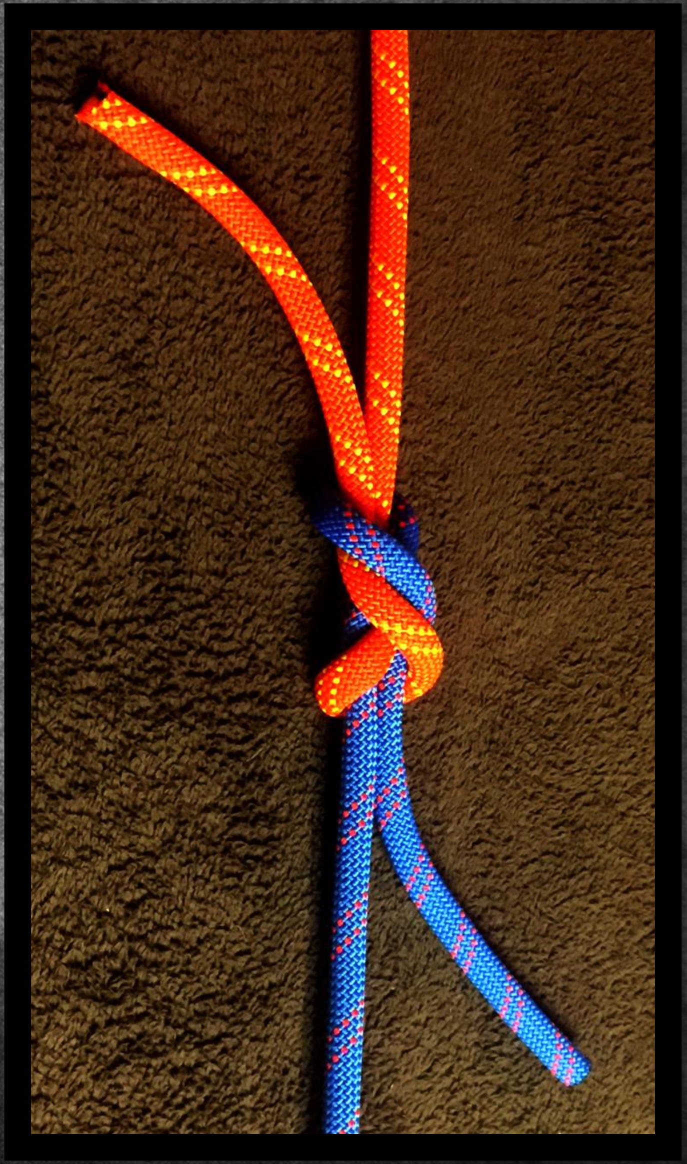
Surgeon's Knot

Utility knot

Used to tie 2 ropes or webbing of equal diameter together when there is not enough tail to safety. (Aids in larger rescue packages)

Efficiency ≈ 50% (4,500lbf Rope)

Efficiency ≈ 35% (2,800lbf Webbing)



Sheet Bend (Becket Bend)

Used to tie the ends of non-congruent ropes together

Use to tie ½ inch Kernmantle to 8mm Prusik

Use to tie 8mm to Tubular Webbing

Larger rope must have "safety" to keep from spilling

Efficiency ≈ 50% (4,500lbf Rope)

Efficiency ≈ 35% (2,600lbf Webbing)

Double Sheet Bend

More secured method than the Sheet Bend used to tie the ends of non-congruent ropes together

Use to tie ½ inch Kernmantle to 8mm Prusik

Use to tie 8mm to Tubular Webbing

“Larger” rope must have “safety” to keep from spilling

Efficiency ≈ 50% (4,500lbf Rope)

Efficiency ≈ 35% (2,600lbf Webbing)

Tensionless Hitch

The most efficient knot to tie.

Holds a suspended or tensioned load

Should be used on anchor points at least 4 inches or greater with 4 wraps (Capstan or Kootenay)

Used to gain secure control of a loaded line by wrapping the rope around a post or tree several times

100% knot efficiency (9,000lbf)

Girth Hitch

Lark's Head, Cow Hitch

Static anchor, gives 2 working ends of the rope/webbing (horizontally). Used in patient packaging on the Backboard, SKED and Stokes Litter. Secures a rope to a fixed object

Should not be used for an anchor on life safety rope

Efficiency ≈ 70% - Symmetrical Tension Required
(6,300lbf Rope)
(2,800lbf Webbing)

Double Girth Hitch

Binding static anchor, gives 2 working ends of the rope/webbing (vertically). Secures a rope to a fixed object

Should not be used for an anchor on life safety rope

Efficiency ≈ 70% - Symmetrical Tension Required

(6,300lbf Rope)

(2,800lbf Webbing)

Clove Hitch

Patient packaging

Securing a rope to a fixed object

Should not be used as an anchor on life safety rope

This knot allows rope to be tightened

Efficiency ≈ 60%
(5,400lbf Rope)
(2,400lbf Webbing)

Prusik Hitch

For hauling (haul cam)

For ascending rope and Self-Rescue

Jumper or Prusik Bypass when applying 8mm Accessory cord on ½ inch Kernmantle rope.

Used in tandem on the safety line (belay line) (Tandem Belay)

Used as a progress capture device (ratchet cam)

Efficiency ≈ 1,200lb^{creepage} 3,400^{slip}

Asymmetrical Prusik Hitch

3-on-2 Prusik

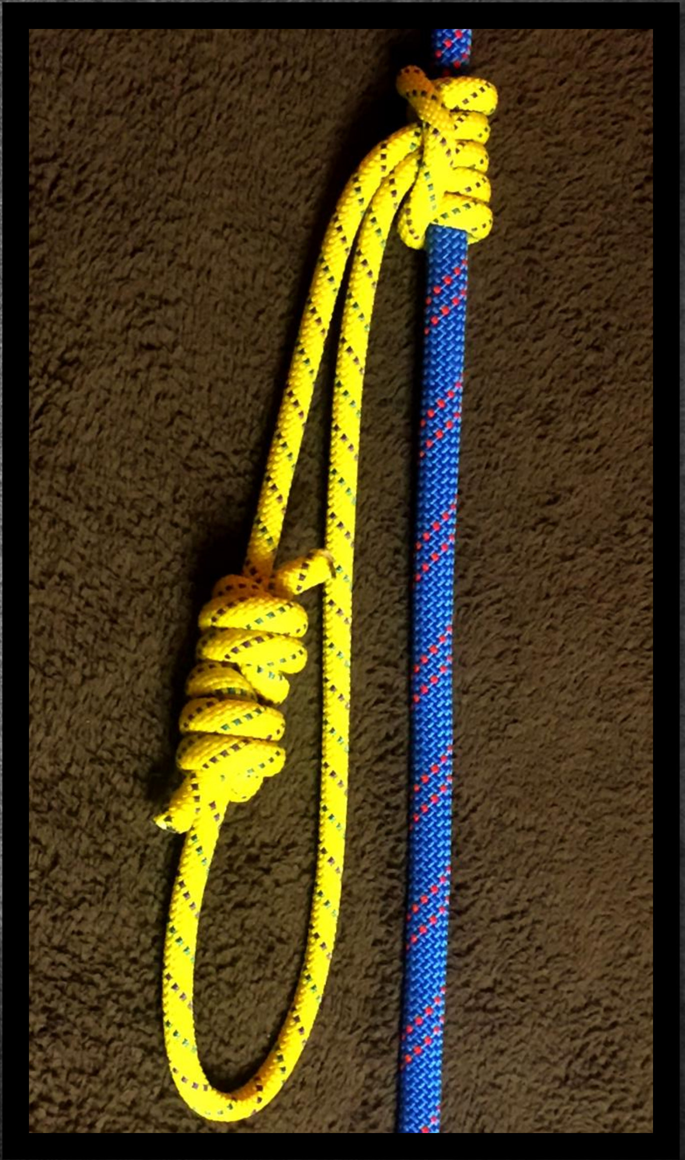
For ascending rope and Self-Rescue

Jumper or Prusik Bypass when applying 8mm Accessory cord on ½ inch Kernmantle rope.

Used in tandem on the safety line (belay line) (Tandem Belay)

Used as a progress capture device (ratchet cam)

Efficiency ≈ 1,000lb^{creepage} 2,000^{slip}



Klemheist Hitch

For ascending rope and Self-Rescue

One advantage is that webbing can be used as an alternative to cord.

The Klemheist is easier to slide up than a Prusik.

Jumper or Prusik Bypass when applying 1 inch tubular webbing on ½ inch Kernmantle rope.

Efficiency ≈ 1,100lb$^{\text{creepage}}$ 3,300$^{\text{slip}}$

Purcell Prusik Hitch

A Purcell Prusik is a somewhat longer loop than the normal Prusik. It is used around the cord loop itself to form a loop. The loop is easily adjusted in length and position.

This loop could also be tied in a prusik around a ½ inch kernmantle rope

For ascending rope and Self-Rescue

Used as an edge restraint

Used as an adjustable loop for backup or foot loop

Efficiency ≈ 1,000lb^{creepage} 3,300^{slip}

Münter Hitch

Italian Rolling Hitch

Used to lower equipment, single person safety belay line

Single person load

300lb Load Capacity

Super Münter Hitch

Used to lower equipment, two person safety belay line

Single or two person load

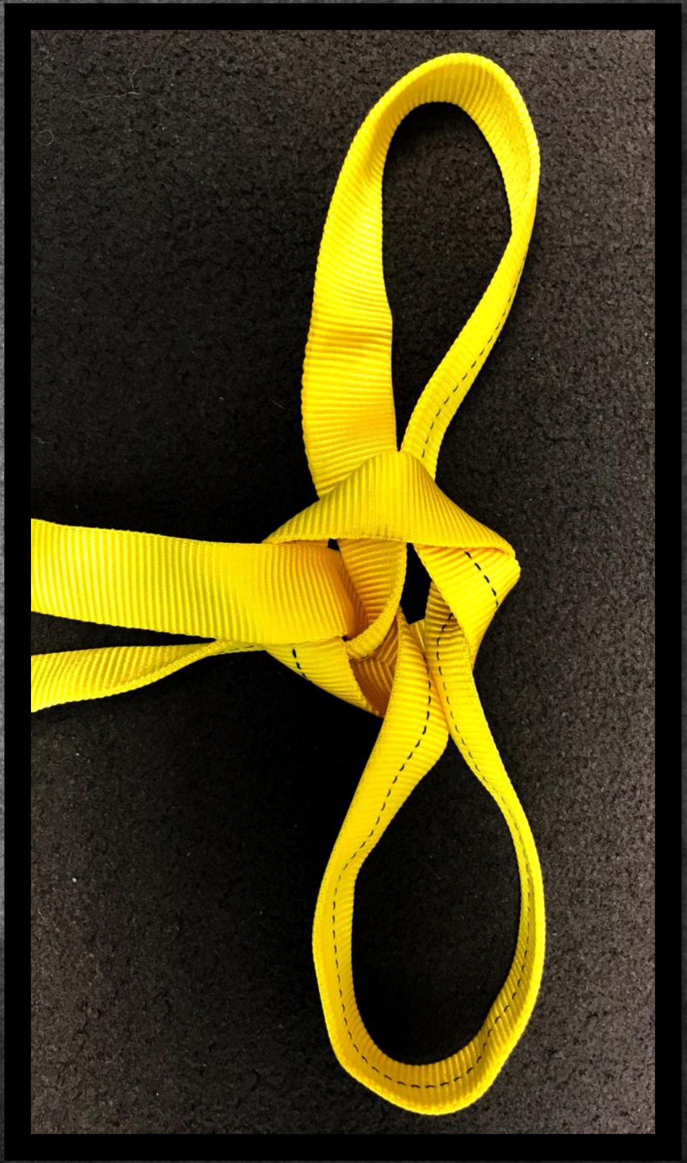
600lb Load Capacity

Note: Ensure the bag end of the rope is running on the spine of the carabiner

Hand Cuff Knot

Used to position a patient's hands or restrain a combative patient

This is used "as needed" for potential patient retrieval



Mariner's Hitch

Used to release or transfer a load without "shock"

To relieve tension off of a loaded rope in a lowering system

Note: Ensure the carabiners are all locking!

3:1 Radium Release Hitch

Used to release or transfer a load without "shock"

To relieve tension off of a loaded rope in a lowering system

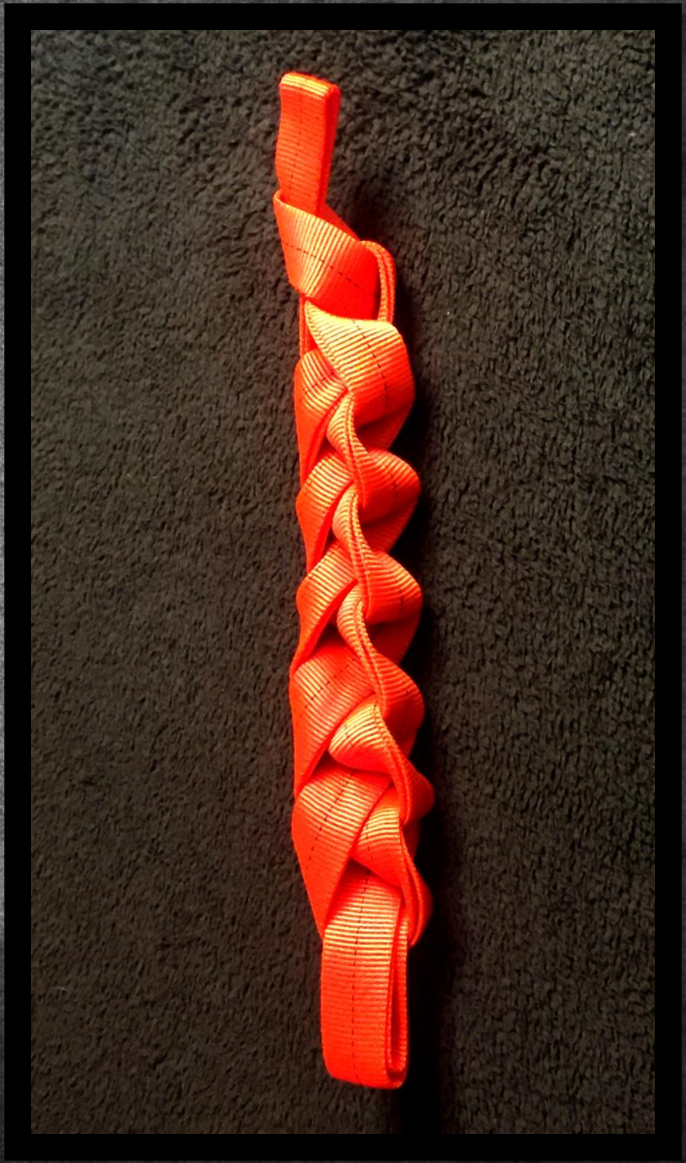
Daisy Chain

Used to shorten and store webbing or rope

Prevents tangling

Reduces Storage area requirements

Commonly used coil for washing



Lobster Tail

Used to shorten and store larger pieces of webbing or rope

Prevents tangling

Reduces Storage area requirements

Anchors

Anchor Definitions

Anchor

An Anchor is a general term for the combination of everything combined. Single connection point (e.g. tree, boulder, camming device, etc.).

Anchor Point

An Anchor Point is a single object or component used either alone or in combination with others to create an anchor system capable of withstanding a significant force.

Anchor System

An Anchor System is one or more anchor points connected in order to provide a secure connection. Multiple anchor points rigged together creating a redundant system.

Deviation

Redirects the natural fall line of the rope on the rock face. A deviation point may or may not to be subjected to the same force as the primary rig point.

Anchor Definitions

Directional

Rigging technique to change the natural line of a rope with a carabiner or pulley attached to an alternative anchor.

Focal Point

A location, floating or fixed, where all rigging is directed for anchor points. This concept disciplines rescuers to construct rigging which joins together at an efficient point, rather than unwittingly resorting to wherever the knot that joins all anchor points ends up due to the length of material used; the latter can result in an awkward spot to manage rope handling tasks.

We will always try to engineer our anchor systems with housekeeping in mind. Though a single “bombproof” anchor may be strong enough to support an entire rescue system, including multiple load bearing lines, we may still build a second anchor for convenience and cleanliness and to allow more workspace for rescuers. Rescue systems are often more efficient and easier to operate with redundant load bearing lines rigged on separate anchors.

Anchor Definition

Anchor: A structural system or single component capable of sustaining a load.

Bombproof: Capable of sustaining the actual or potential forces exerted on the rope rescue system without possibility of failure.

- A bombproof Anchor will not fail!
- A bombproof Anchor will not move!

Natural: Trees, Boulders.

Artificial: Manmade Objects, including Buildings, Vehicles, Pickets in soil, & techniques in ice.

Anchor Definitions

E - Equalized

In a system with multiple anchor points or multiple strands of anchor material, the various components of the anchor system should bear roughly equal parts of the load. Self-equalization is not required. Pre-equalize the anchor for the anticipated direction of pull.

R - Redundant

Failure of any one component of an anchor system should not lead to complete anchor failure. For example, construct the anchor system so that if one strand of software is severed, at least one additional strand capable of supporting the load will remain intact.

N - Non–Extending

Failure or shifting of one element in the anchor system should not cause significant movement of the load. This is why we fix and focus our multi-point anchor systems and why we generally avoid self-equalizing anchors. The location of anchor points relative to one another is also a factor in this stage of anchor system analysis. Failure of one anchor point should not result in excessive swinging of the load toward the remaining anchor point or points.

Anchor Definitions

S – Solid

Choose the strongest available anchor point. If no single anchor point seems strong enough then combine multiple anchor points until you are confident your anchor system is strong enough. Build your anchor with materials at least as strong as the weakest point in your system.

T – Timely

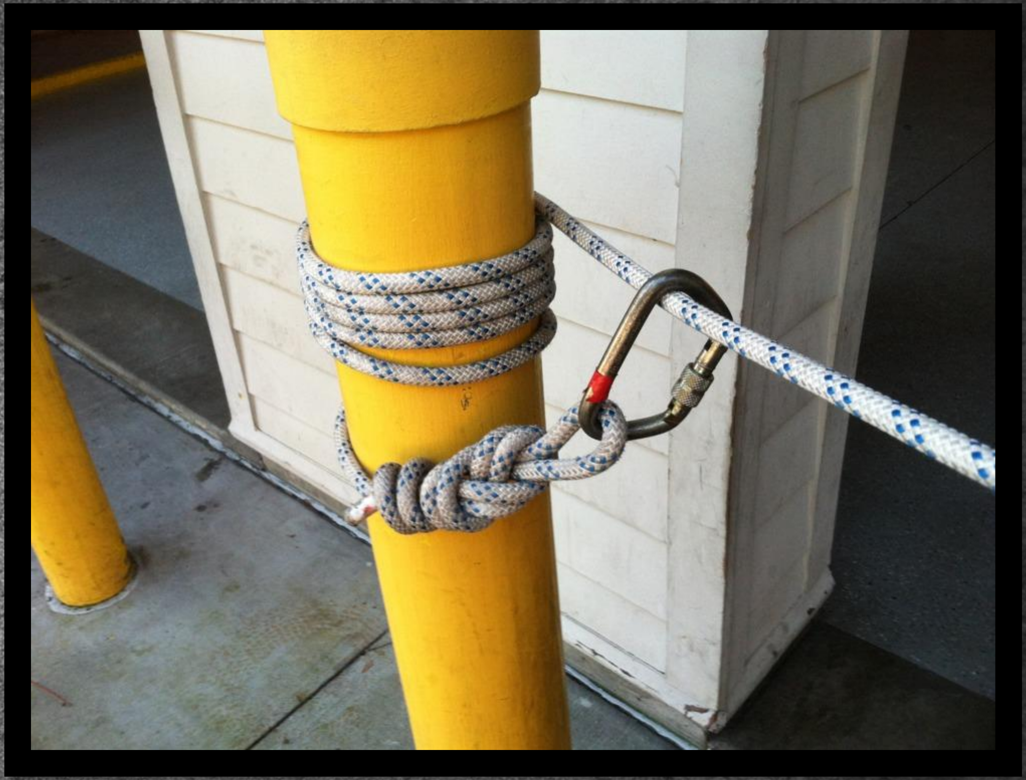
Balance the need for strong anchors with the need to reach your patient as quickly as possible. Simpler is usually better.

Single Point Anchor

Within a Single Point Anchor, there are two types of connections:

Indirect for webbing, cord, and other such material.

Direct which uses the actual working or belay lines themselves.



High Strength Tie Off

Multi-Point Anchor

Multi-Point Anchor

Often, single point anchors are either non-existent or marginal, thus necessitating the need for multipoint anchor systems.

Rigging a backup or secondary connection to a separate anchor.

Available anchor points are not exactly where they need to be.

A directional shift is possible during the evolution

Types of Multi-Point Anchors

Four Types of Multipoint Anchor Systems:

1. Slack Anchors Systems: These are non-tensioned systems are more for backups.

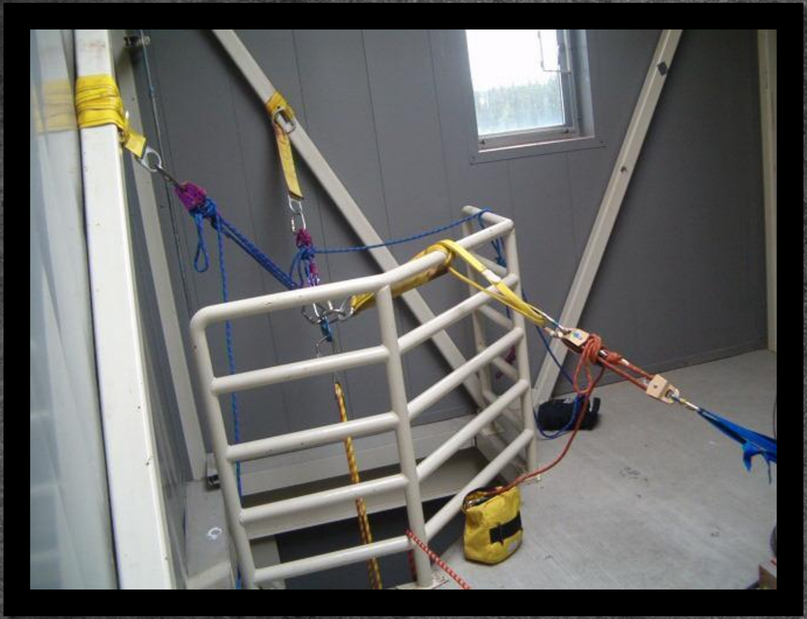
2. Tensioned Anchor Systems: These utilize some form of tensioned mechanical advantage rope system between anchor points. Pre-Tensioned back-ties, non-working 3:1 MAs, AZTEK's, Munter Mule are examples.

3. Load Sharing Anchor Systems.

4. Load Distributing Systems.

Fixed Multi-Point (Load Sharing)

Shared & Distributive Anchors



Floating Anchor with Back-Tie

Specified Multipoint Anchors

Load Sharing Anchors (LSA) are theoretic in the distributive attributes. They're clean and generally efficient. The point of disproportion happens at the point when a load shifts and the anchors won't accommodate and safe transition between the two anchors. This could result in a slacked line, and this is not what this anchor system is intended for. So if there is ever concern where the load could shift, don't use an LSA, but rather something more accommodating. That said LSAs are the preferred Multipoint Anchor. They cleaner, faster, non-extending, safer and have a greater operational application that LDAs.

Load Distributing Anchors

Load Distributing Anchors (LDA) are similar to its Load Sharing cousin, but differ at three points:

1. A single piece of material to connect anchor points.

2. Will theoretically distribute the load when a shift does occur.

3. Should an anchor point fail, redistribution still remains.

Bombproof Multiple Anchor Points

Extensions, Back-Ties & Redirects

Extensions, Back-Ties & Redirects
As with all anchor systems, making sure extension, back-ties, and redirects meet all the criteria of EARNEST.

What does this stand for?
Equalize your anchors so they are always in tension.
Angles are minimum.
Redundant.
Never **E**xtending if failure occurs, and
Strong.
Timeliness is important but better correct than hastily done and wrong.

Opposing Anchors on AHD

Natural Anchors

Natural anchors, such as trees and blocks of rock, can make good anchors and help you conserve other gear. However, you need to assess the integrity of these features before incorporating them in an anchor system.

Trees: Before you use a tree, check to make sure it is alive, well-rooted and solid. Be suspicious of trees growing out of cliffs and always test a tree by pushing against it. A good rule is to only use a healthy tree that is at least 12-inches in diameter. To use a tree as an anchor point, you can circle a runner around the base of the tree and clip the ends together with a carabiner.

Rock features such as horns and chockstones (a stone that’s tightly wedged in a crack) are frequently used as part of an anchor. When assessing the integrity of these, check to make sure they are solid and well attached. Look for brittle rock and cracks that indicate a weakness. With horns, you can loop a runner over the top and clip it to the rope. To attach the rope to a chockstone, circle a runner around the feature and clip the ends together with a carabiner.

Fixed and Removable Anchors

Bolt

Piton

Fixed anchors are any type of artificial gear that once placed is left permanently "fixed" to the rock. To attach the rope, you clip quickdraws or runners to the gear. Two common examples of fixed anchors are bolts and pitons.

Just as with natural anchors, fixed anchors need to be assessed for signs of weakness. If you see cracks or excessive corrosion or wear, the fixed gear may not be trustworthy. If the bolt or piton moves in any direction, don't use it. Be wary of out-of-date gear, especially ¼-inch bolts and sheet-metal-style hangers. The current standard bolt size is 3/8 to ½ inch in diameter.

Removable anchors, such as cams and stoppers, are used where natural and fixed protection are not available.

Passive Protection Anchors

Nuts, the mainstay of passive pro, have many alternative names, including chocks, stoppers and tapers. All of these terms for basic passive pro refer to some variety of a tapered metal wedge attached to a wire cable that has a loop on the end.

The wedge gets slipped into a crack and the other end gets linked to an anchor. The wedge is engineered to jam solidly into place when a load is placed on the nut's wire. Some nuts also have cutout areas for better fit on uneven rock surfaces.

Nuts come in sizes ranging from 1 through 13. Exact dimensions for each size vary slightly, depending on the nut maker and the nut shape.

Generally, any nut below size 7 is considered a micro nut and should not be used in Rescue.

Passive Protection Anchors

Hexentric: A hex can be used in both tapering and parallel-sided cracks, as well as widening cracks. An asymmetrical six-sided tube, a hex is placed like a nut: directly into a narrowing section of the crack. A downward pull on the wire rotates the hex and wedges it tightly in the crack. This rotational placement allows it to get a secure hold in a parallel-sided crack.

Tri-Cam: can be placed in a parallel-sided crack, a pocket or a horizontal crack. Rounded on one side and having a point on the other, it's useful in cracks that are too large or straight-sided for a nut to hold well. Unlike a spring-loaded cam, it has no moving parts. A tri-cam is placed directly into a crack and cammed into place. Force applied to the sling rocks the curved edge and forces the point into the rock.

Active Protection Anchors

Cams: (Friends) typically feature three or four curved pieces of aluminum, called cam lobes. When you pull the spring-loaded trigger wire, these chunks of metal retract and make the device narrower. This allows you to slide the unit inside a crack. When you release the trigger, the cam lobes expand to fit the rock.

Spring Loaded Wedges: These pieces of active protection have a small sliding piece that expands the size of the wedge once it is placed in a crack. Similar to placing a cam, you pull the spring-loaded trigger to retract the sliding piece, place the wedge into a narrow crack, then release the trigger to allow the sliding piece to return to its original position.

Anchor Systems

General guidelines

- Ensure anchor stability
- Know qualities of anchor materials
- Ensure the anchor focal point is in line with the rope path and edge transition
- Check for sharp edges and pad when necessary

Welded Pad Eye Anchors

General guidelines

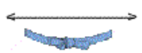
- Ensure metal is at least ¼ inch plate
- When viewing welds ensure integrity
- Ensure the weld is at least 4 inches in length by ¼ inch fillet (1 inch of ¼ fillet weld on 6010 or 7018 rod equals 2,500lbs per inch)
- Check for sharp edges if using software, use edge protection as needed

Anchor System Types

- Single point anchors
- Multipoint anchors
  - Load Sharing
  - Load Distributing
- In-line anchors
- Extending anchors
- Directional anchors
- Tensionless / “No Knot”
  - Cheater system
- Picket System

Common Configurations

One-Inch Webbing Anchors: Minimum Breaking Strength of Common Configurations

	Webbing Strength	Girth Hitch	Single Loop 90°Internal Angle	Wrap 2, Pull 1 90°Internal Angle	Redundant Double Loop 90°Internal Angle	Wrap 3, Pull 2 90°Internal Angle	Basket 90° Internal Angle	Double Loop 90°Internal Angle	Redundant Wrap 2, Pull 1 90°Internal Angle
									
Tubular Web lbf (kN)	4,340 (19.31)	4,799 (21.35)	4,832 (21.50)	5,510 (24.51)	7,777 (34.59)	7,899 (35.14)	8,464 (37.65)	8,716 (38.77)	9,700 (43.15)
Flat Web lbf (kN)	6,000 (26.00)	8,776 (39.04)	6,130 (27.27)	8,098 (36.02)	10,786 (47.98)	10,507 (46.74)	12,989 (57.78)	10,538 (46.88)	11,458 (50.97)

Anchor Angles and Forces

The horizontal spacing between anchor points and the length of slings that you use to connect the points are critical in creating a reliable anchor. This is because the amount of force applied to each anchor point depends on the angle formed by the slings coming together. The smaller the angle, the less force each anchor point will receive, and conversely, the larger the angle, the more force each point will receive.

For example, in a two-piece anchor with an angle of 60 degrees, each anchor point receives 58% of the force. Increase the angle to 90 degrees and the force on each ramps up to 71%. An anchor with a 120-degree angle, distributes 100% of the force to each anchor point.

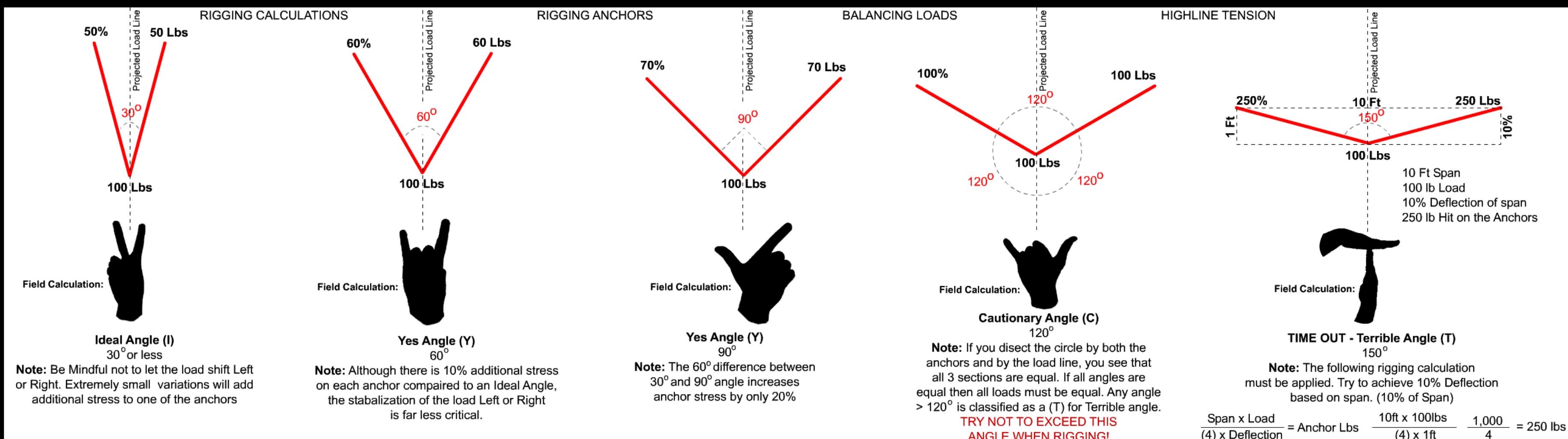
In order to keep the force on each anchor point from reaching dangerous levels, the angles formed by the sling or slings in your anchor system should never be greater than 60-90 degrees. This doesn't mean that you can't use anchor points that are spread far apart from one another. To create an angle that's less than 60-90 degrees you can extend the anchor points with long slings or 8mm Accessory Cord.

Rigging Angles

In Rescue, it is common to create a centralized anchor while sharing two anchor points. There are many reasons why we would use two or more anchor points; sometimes this is because the anchors are not exactly where we need them to be and other times it could be because the anchors are perceived as “marginal”. Although it is ill-advised to use marginal or questionable anchors unless they are backed up sufficiently, the following information should help you in pre-determining how much stress you are actually applying to the anchors during a rescue evolution before they are loaded.

Many rescue instructors, firms, and institutions may refer to angles as “Ideal”, “Yes”, “Cautionary” and/or “Terrible” angles and this quick overview may help further explain and/or challenge your understanding of these meanings.

Critical Angles



30° "Ideal" Angle:

30° "Ideal" Angle: An "Ideal" angle is an angle that is between 0° and 30°. What makes the angle considered to be "Ideal" is that the weight of the load is split evenly between both anchors. For example, a 30° load holds approximately 50% of the weight. In the diagram, you can see how a 100lb load only has 50lbs on each anchor which is 50% of the 100lbs. If there was an "S" type load cell* on each of the anchors connected to the rigging, you could see the results as you modified the angles.

A challenge to the idea of the angle being "Ideal" is that if there is a slight shift of the load, the anchor opposite of the load shift will receive a very rapid and massive amount of load gain. If the anchor is marginal, it could result in anchor failure. The easiest way to identify if the anchor angle is approximately 30° is by making a peace sign with your hand. The angle between your index (pointer) finger and your middle finger is roughly 30°.

“Yes” Angle:

“Yes,” angles are typically between 30˚ and 90˚. The considerations for “yes” angles are that there are very insignificant increases in weight to the anchors but with quite a large range of angle increase. Overall, as you can see on the diagram, there is an increase of weight between the 30˚ and 90˚ angles of only 20% to each anchor. This angle range of 50˚ having a 20% increase to each anchor is the primary reason for the classification of “Yes” angles.

These angles are easily identified due to the load line and anchor lines looking like the letter “Y”. A shift in the load also must be much more dramatic before additional anchor stress is achieved.

60° "Yes" Angle:

60° "Yes" Angle: By increasing the 30° angle to a 60° angle between the anchors creates a 10% increase in anchor stress. As seen in the diagram, the doubled angle only shows the additional 10lbs per anchor to hold a 100lb weight. The 60lbs of anchor stress per anchor to hold the 100lbs is far more stable than the ideal angle if the load were to shift to the left or the right. Whenever possible, try and achieve a 60° angle for balancing loads.

A quick field calculation for assessing a 60° angle is by holding up the "Hook 'em Horns" hand signal. This is achieved by holding up your index (pointing) finger and your pinky finger while tucking the two middle fingers with your thumb. This natural span and the angle is very close to a 60° angle.

90° "Yes" Angle:

90° "Yes" Angle: This angle achieves a right angle which is very easy to identify and verify in the field. You could use a book, or a phone or almost anything lying around that has a right angle in order to visually see this angle. Also, if you make the letter "L" using your index (pointing) finger and your thumb you can also see this angle. A 90° angle only places 70% of the load on each anchor. As seen in the diagram, a 100lb load only has 70lbs on each anchor.

120° "Cautionary" Angle:

120° "Cautionary" Angle: The "Shaka" or "Hang Loose" hand signal is a rough estimation used in the field for a 120° angle. The reason for this "cautionary" angle is due to the forces applied to the anchors. At this angle, the full weight of the load is being applied to both anchors evenly. In the diagram, it shows a 100lb weight and both anchors holding the 100lbs. the reason for this is a simple formula. If you dissect the circle by both of the anchors and the load line, you will see that all three sections are equal. If all angles are equal, then all loads must be equal. The symmetrical tension on the anchors and load line should indicate that each of the anchors should be able to hold the load by themselves. Never use "marginal" anchors when rigging in this vector angle range. A slight change in angle will cause a dramatic increase of stress put on the anchors. Any angle that is greater than 120° is classified as a "Terrible" angle. Without a clear understanding of physics, never try and rig outside of 120° angle.

150° "Terrible/Time-Out" Angle:

150° "Terrible/Time-Out" Angle: Although most would classify a 150° angle as terrible, my thoughts are a little different. Under normal circumstances, I would not try and rig an angle this wide due to the excessive stress placed on the anchors, but in certain applications, they are very useful. Typically, when applying these wide angles their uses are not only wanted but may be very necessary. This is usually the case when building Highline systems, Tyrolean systems or some Offsets. My typical name for the angles is not "Terrible" but more like "Time Out". The main reason is I believe you should take the time when building these style systems and do the math! Physics play a huge role in the failure of these systems in every part. These wide angles must be calculated and all equipment associated with these systems is an integral part of the entire degradation of the system, but most certainly the anchors. Very flat trajectories yield very high stressors for the anchors in these systems. I am not saying you could not build a system that had a 2.5% deflection, but if you do, understand the limitations of the entire system.

Deflection

Deflection is key when rigging anything beyond 120˚.

First, let's assume some basic guidelines. We would be using ½ kernmantle static ropes as well as all "G" rated equipment. The load would not exceed the NFPA two-person load of 600lbs. As all of this equipment would be rated for the coveted 15:1 safety factor (9,000lbs), in all actuality, we would be attempting to hit a 10:1 safety margin. A 10:1 safety factor in our systems is more like a "Holy Grail", but with proper rigging and calculations, it could be achieved.

$$\frac{\text{Distance x Load}}{\text{(4) x Deflection}} = \text{Anchor Stress}$$

Real World Application

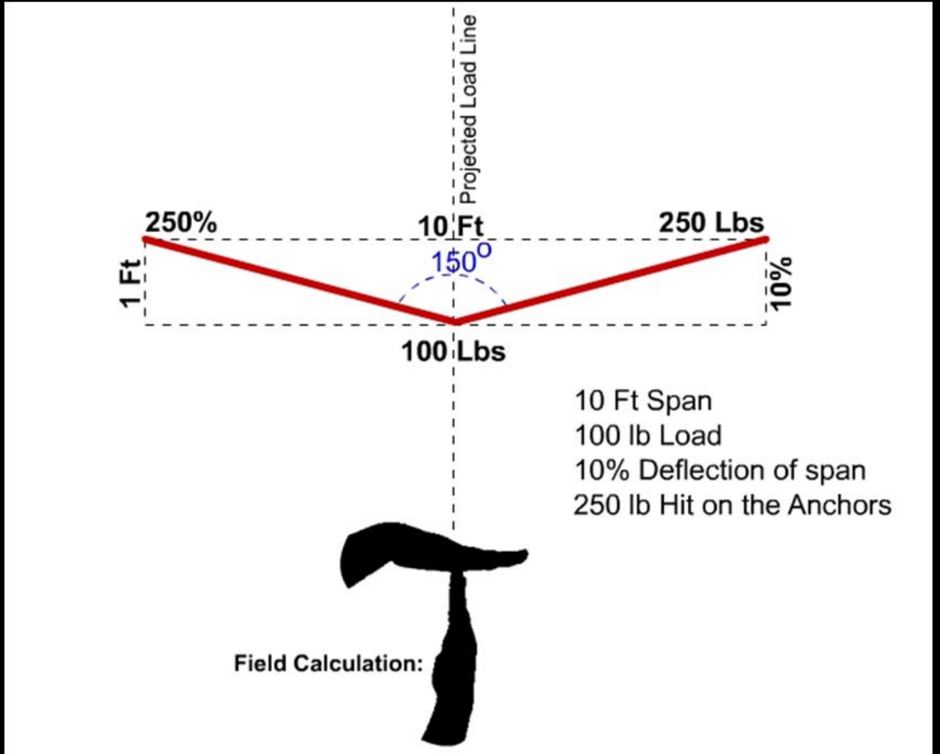
Estimate the load and multiply it by the distance between the two anchors.

Let's say we have a load of 400lbs. and a distance between the anchors of 100ft. we would multiply the load of 400lbs times the distance of 100ft totaling 40,000lbs. Now you can see that the "G" rated equipment would fail since its ratings are around the 9,000lb mark. At this point, you should be looking at "Sag" more than anything else in order to reduce that tension. Here is the simple way to calculate "Sag" or deflection. If we are using a single ½ inch kernmantle rope, we would want no less than 10% deflection. A 10% deflection of the entire distance between both anchors, which is 100ft distance, would be a 10ft deflection. Multiply 4 times 10, and you get 40. Now, 40,000 divided by 40 equals 1,000lbs. This shows that a 400lb load with a distance between anchors of 100ft and a deflection of 10ft (10% of the distance) would generate a 1,000lb hit on the anchors.

Deflection

As seen in the diagram, we are using the same formula but a weight of 100lbs, a span of 10ft, and a deflection of 1ft. If these numbers are plugged into the formula, you can see that there are 250lbs of force on each anchor.

When using this formula, you are attempting to achieve a 150° angle, regardless of the scale between anchors. If less deflection is required, additional rigging must be applied to keep a 10:1 safety factor.



TIME OUT - Terrible Angle (T)

150^{o}

Note: The following rigging calculation must be applied. Try to achieve 10% Deflection based on span. (10% of Span)

$$\frac{\text{Span x Load}}{\text{(4) x Deflection}} = \text{Anchor Lbs} \qquad \frac{\text{10ft x 100lbs}}{\text{(4) x 1ft}} \qquad \frac{1{,}000}{4} = 250 \text{ lbs}$$

Confined Space Tripod

Load Management Solution

Tripods are often used for access and standby rescue with confined space operations where a symmetrical unit is setup over the top of a hole. One of the legs will often incorporate a hauling mechanism attached to a line which runs up to a pulley at the tripod head and then down the hole to an operator. The head is normally hinged so the feet are hobbled to prevent them spreading. In this configuration everything is stable and there is no requirement for guy lines or anchors.

Tripod

Three legged device which provides an over head lift point . Adjustable legs to allow set up on uneven surfaces. Can be adjusted from 6-10 foot, depending on type.

Precautions:

- Avoid side loading
- The resultant should fall inside the footprint of the tri-pod
- Do not exceed rated capacity
- Added equipment reduces the amount of head room
- Safety line attachments should be independent of tripod

Technical Rescue Tripod

Friction Management Solution

In technical rope rescue applications, a load normally needs to be managed outside the footprint of the tripod. The footprint is an imaginary perimeter line that can be drawn connecting all of the feet. The load may start at the base of a structure and then, once at the top, be moved inboard and placed safe on the deck.

Arizona Vortex

- Artificial high directional systems (AHD),
- All-inclusive kit
- Precision two-piece head
- A-frame with adjustable leg lengths
  - Gin Pole
  - A-Frame
  - Tri-Pod
- Artificial high directional
- Pulleys can be attached
- Use with high lines and tracking line offsets
- Rope access

TerrAdaptor

- Artificial high directional systems (AHD),
- All-inclusive kit
- Precision 3-piece head
- Adjustable leg lengths and Feet Attachments
  - Gin Pole
  - A-Frame
  - Tri-Pod
  - Quad-Pod
- Artificial high directional
- Pulleys can be attached
- Use with high lines and tracking line offsets
- Rope access

Crane Operations = Danger

Powered Winches and other power equipment such as Overhead Gantry Cranes, or Pickers should not be used to make a rescue lift

If the rescue package gets "Hung-Up" haulers need to **STOP immediately!**

Forcing the system by pulling harder may result in catastrophic line failure or further injuries to the patient and/or litter adjunct.

Anchor Points to Avoid

- Unsupported Handrails
- Non-Bulk masonry
- Insulated piping
- Corroded metals
- Cast Iron and small piping
- Fire hydrants or Monitors
- Horizontal Scaffolding





Angular Vector Forces

Angle   Force on Anchor

0˚ = 200%

30˚ ≈ 190%

45˚ ≈ 185%

60˚ ≈ 170%

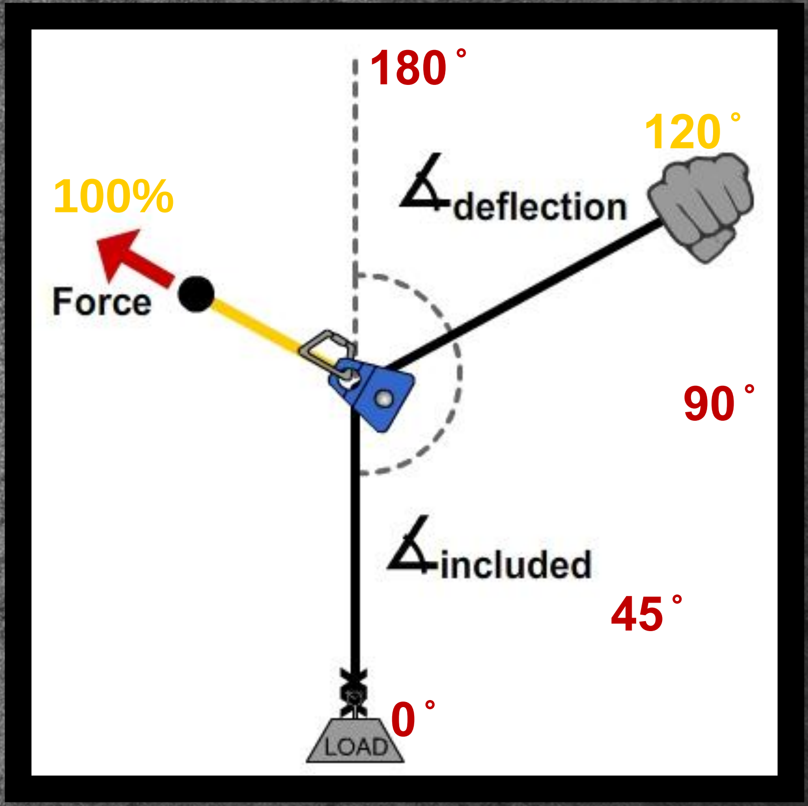
75˚ ≈ 160%

90° ≈ 140%

120˚ ≈ 100%

150˚ ≈ 50%

180˚ = 0%



On Rope

Rescue Fundamentals:

- Do not step on rope
- Secure equipment at all time
- Do not drop/throw gear
- Rope and webbing must be padded at all sharp contacts
- Use the Buddy System (Check your buddies gear/have your buddy check yours)
- Rig rescue systems with redundancy. (1 is none – 2 is one)

Rescue Fundamentals:

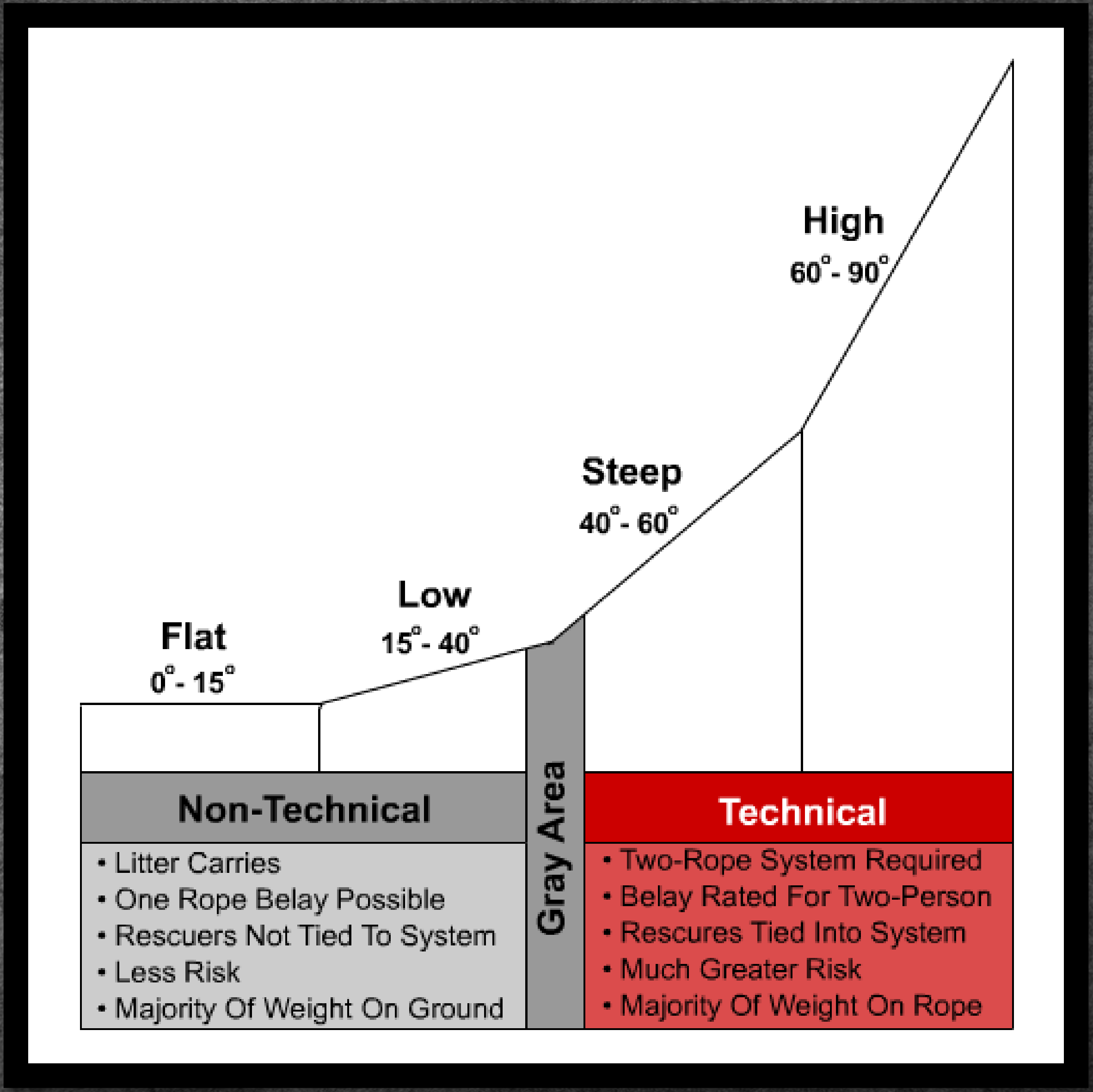
- A Tri-Link can be used anywhere a carabiner can be used. A carabiner cannot be used anywhere a Tri-Link can be used.
- Any Haul system could be used as a Lowering system. Inversely, a Lowering System cannot be used as a Haul System.
- A Butterfly Knot could be used anywhere a Directional 8 (In-Line 8) could be used, A Directional 8 cannot be used anywhere a butterfly could be used.
- A Prusik Hitch could be used anywhere a rope grab could be used. A rope grab cannot be used anywhere a Prusik Hitch could be used.
- All systems should be able to pass a Whistle Test.
- All systems should pass a Critical Point Test

Terrain Types (Ground Based)

Rope rescue is defined as any rescue attempt that requires rope and related equipment to safely gain access to, and remove patients from, hazardous geographic areas with limited access such as mountains, high rise buildings, above or below grade structures, by means of a rope system. Rope rescues are divided into two general categories; non-technical and technical.

Non-technical evacuation are those of less than 40 degree inclination. Technical evacuations are considered those from 40 degrees to 90 degrees. Technical evacuations require the dispatch of a Technical Rescue Team. Technical rescues will be dispatched as High-Angle incident.

Terrain Types (Ground Based)



System Type (Arial Based)

Once the decision is made that it is a Technical Rescue, there are 5 categories of Arial Based operations that should be considered. These categories may change the way the anchors and systems are rigged to meet the additional forces that will be encountered.

0° - 15°: Fall Line or Vertical Systems – These systems use tag lines to gain a minor angle change to clear obstacles directly underneath the anchor.

15° - 30°: (Minor) Offsets – These systems use tag lines or guiding lines to achieve a landing zone no more than 30° from the anchor. See Offsets Section

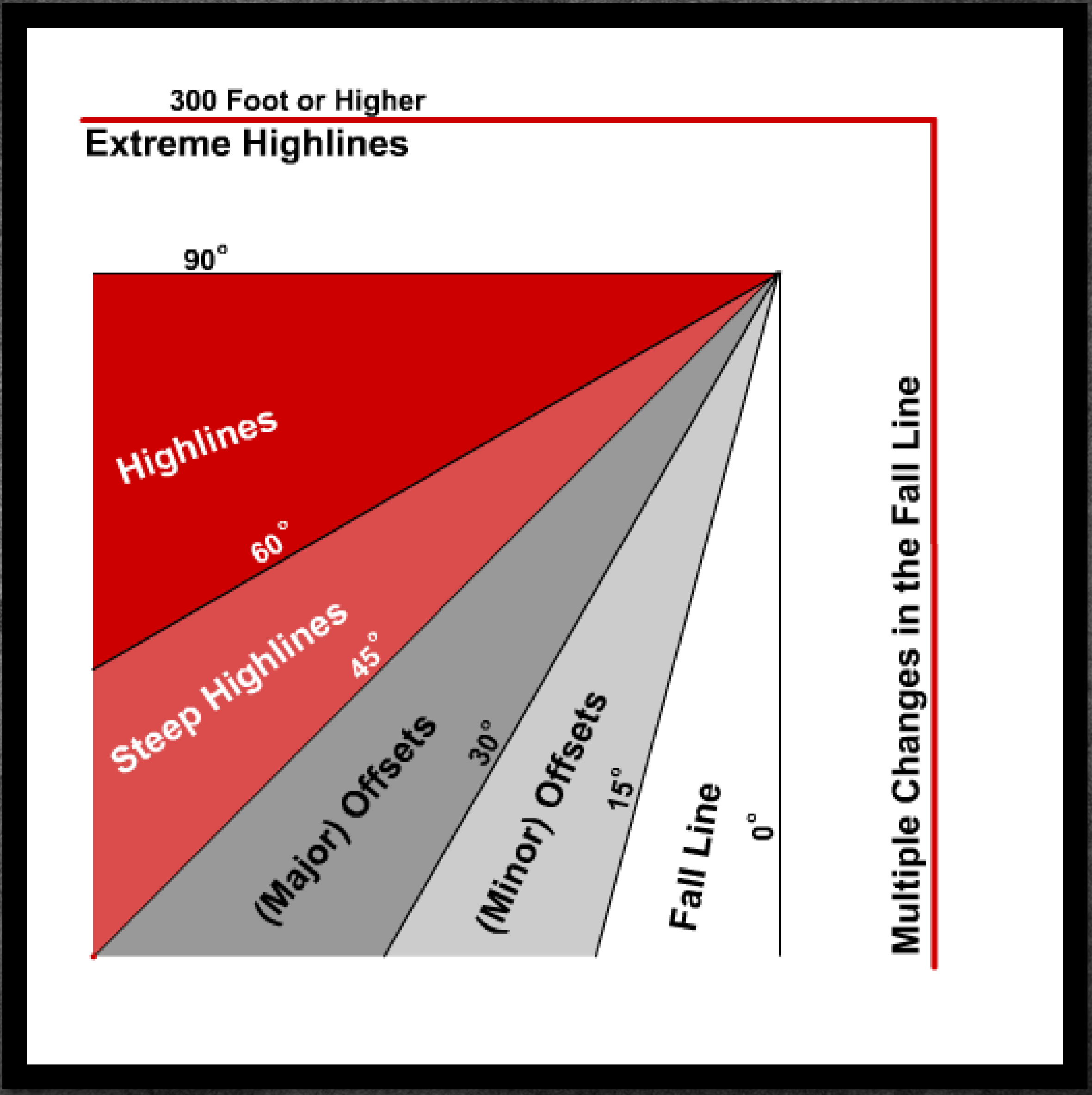
30° - 45°: (Major) Offsets – Major offsets usually employ some type of mechanical advantage system to aid in the angular drop. This is due to the excessive forces that it takes to get the load that far offset from the anchor, usually no more than 45°. See Offsets Section

System Type (Arial Based)

45° - 60°: Steep Highlines – These systems are built in the fashion of a highline, but due to gravimetric forces, more anchor stress is on the elevated anchor than the lower anchor due to the control line also lowering the load. See Highlines Section

60° - 90°: Highlines – These are Horizontal systems that require knowledge of physics as well as good rigging practices. See Highlines Section

System Type (Arial Based)



Extreme Height Systems

Due to the length of the ropes that are typically deployed in the field, additional precautions may need to be addressed if the operations are higher than 300 foot.

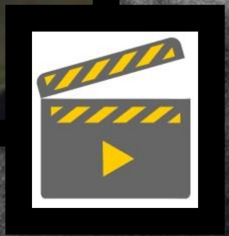
Vertical systems 300 foot or taller are classified as having multiple changes in the fall line. This is because resetting or knot passing must be employed to complete the haul or lower.

Highlines that are taller than 300 foot are classified as Extreme Highlines due to similar situations such as knot passing that could occur during reeving operations.

Rappel:

To descend by sliding down a rope passed under one thigh, across the body, and over the opposite shoulder or through a special friction device.

Rappelling



- The act of descending a rope
- Slow and controlled
- Quick access
- Knot located at anchor
- Bottom belay
- High change direction

Rappelling Commands

- **Quiet!**
- Safety ready? – *Ready*
- Belay ready? – *Ready*
- Rappeller locked off and ready? - *Ready*
- Load the line.
- Transition the edge
- On the Ground – *Acknowledge*

Belay:

The method by which a potential fall distance is controlled to minimize damage to equipment and /or injury to a live load.

Bottom Belay

- **For rappelling only!**
- Fireman Belay
- Exerting force on the main line increases friction on the rappeller's descent control device.
- It is a backup for the rappeller's control hand.

Main line is positioned around the body

Pick Off:

Abseiling to the stuck person, attaching them to your abseil device and then removing them from the rope(s) to which they are attached, then lowering with them to the ground.

Pick Offs

- The transferring of the victims weight onto the rescuers rope system.
- Use the appropriate decent control device

Ascending:

The act of climbing a fixed rope with Prusik loops or mechanical rope grabs such as ascenders .

Ascending

- Ensure at least 2 points of attachment on the rope

- Equipment used
  - - Prusiks
  - - Cam Ascenders
  - - Etriers
  - - Gibbs Device

Climbing:

Climbing is the activity of ascending, especially with the aid of ropes and special equipment. The concept is to reach an end point, or a summit, of a structure usually at or above a patient (victim). This can be done with specific equipment, depending on the difficulty and severity of the climb.

Protected Climbing

- The act of ascending a structure while on rope
- Slow and controlled
- Quick access
- Knot located at climber
- Bottom belay or double bypass lanyard

- Double Bypass Lanyard

Protected Climbing

Rescuers may come across a situation where they cannot reach a victim stranded on a manmade structure with their ladders or they are unable to be lowered from above. In these situations, the rescuer must climb the structure in order to gain access to the victim and set up an anchor or directional change for their rope rescue system.

The rescuer must maintain two points of contact with the structure at all times for safety reasons. At a minimum, the rescuer must carry a drop line long enough to reach the ground from working height. This drop line can be used to hoist a main line, belay line, and any other equipment needed to package and lower the victim to the ground. If the victim is not secured to the structure, the rescuer must also carry a victim harness and any equipment needed to secure the victim to the structure.

Climbing Commands

The following are standard commands between climber and belayer, from the beginning to the end of a pitch. This example involves a female belayer and a male climber.

- Climber: That's me! The belayer above is taking in all the slack rope before putting it into her belay device. The climber calls this when he is tugged by the rope from above, indicating that there is no more rope to take in.
- Belayer: Belay on! The belayer is anchored in and has the rope set up through her belay device. She calls this command to let the climber know she's ready to belay.
- Climber: Slack! The climber needs extra rope in order to make the first move or to finish taking apart his belay anchor.

Climbing Commands

- Climber: Up rope! The climber no longer needs the slack in the rope. Asks belayer to take it in. (This can be used at any point in the climb to signal to the belayer to take up slack.)
- Climber: Climbing! The climber signals that he is ready to start climbing.
- Belayer: Climb on! or Climb! The belayer again signals she is ready for the climber.
- Climber: Watch me! The climber is making a move in which he might fall. Asking the belayer to be ready to catch him.
- Climber: Tension! Same as above.

Climbing Commands

- Climber: Falling! The climber is falling and putting sudden stress on the rope. Belayer should have the rope locked off and be braced for any shock.

- Belayer: Halfway! The belayer lets the climber know that he has half the rope's length left to use.

- Belayer: Feet-three-oh! four-oh, etc. (30 or 40 feet of rope left.) The belayer lets climber know how many feet of rope are left for him to use.

- Climber: Off belay! The climber is tied in to the structure with a personal anchor and no longer needs the belayer.

- Belayer: Belay off! The belayer has taken the rope out of the belay device and is no longer watching the climber.

Climbing Commands

- Climber (rappeller): On rappel! Lets people below know to get out of the way of loose rock and to be ready to grab the end of the rope if necessary to stop the rappeller.
- Rope! Anyone at the top of a structure calls this loudly after looking for a clear space below to throw the rope for a rappel or to send the top rope back down.
- Heads Up! Anyone calls this loudly and repeatedly when stuff is falling until everyone is out of the way.
- Take! Used by the climber at the top of a route, it asks the belayer to take the climber's weight on the rope and lower him down. Take is not used in traditional climbing since the climber is not lowered, but rather expected to anchor in before being taken off the belay.

Climbing Commands

At times you'll even be out of hearing range of your climbing partner. Background Noise can make verbal communication difficult or sometimes impossible.

Use names to avoid confusion when more than one team is within earshot. For example, "John, on belay!" or "Anne, up rope!"

Agree on rope signals when voices can't be heard. Some climbing partners have a system of tugs on the rope to signal their intentions. These are sometimes hard to feel on long routes and aren't always totally reliable.

Use 2-way radios for clear communication on long routes or very windy conditions when you can't hear each other. They can be particularly useful in emergency situations when a lot of information needs to be conveyed back and forth.

Most importantly, decide on a system with your climbing partner before you leave the ground!

Lowering Systems

Lowering Systems:

A rope rescue system used to lower a load under control

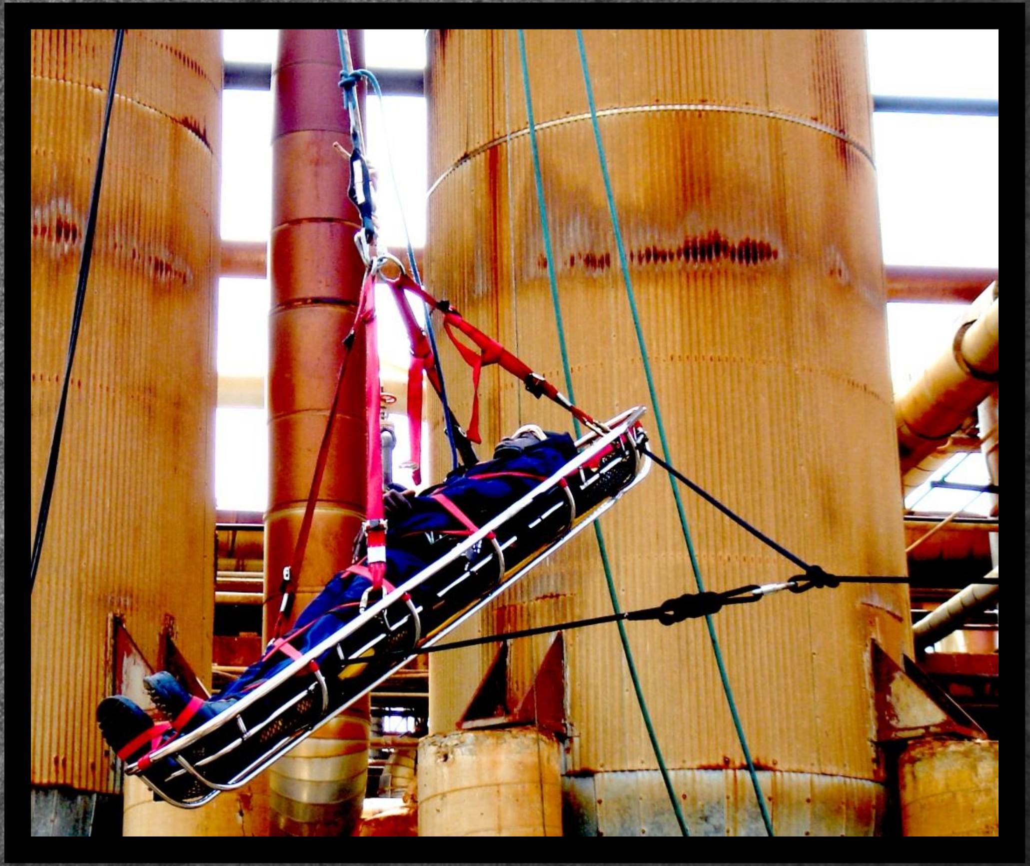
Lowering System Overview

Lowering systems are usually comprised of 3 lines

- Main Line (Primary)
- Safety Line (Secondary)
- Tag Line

There is a multitude of packaging equipment and system configurations that can be rigged to achieve the same end result

- Vertical
- Horizontal

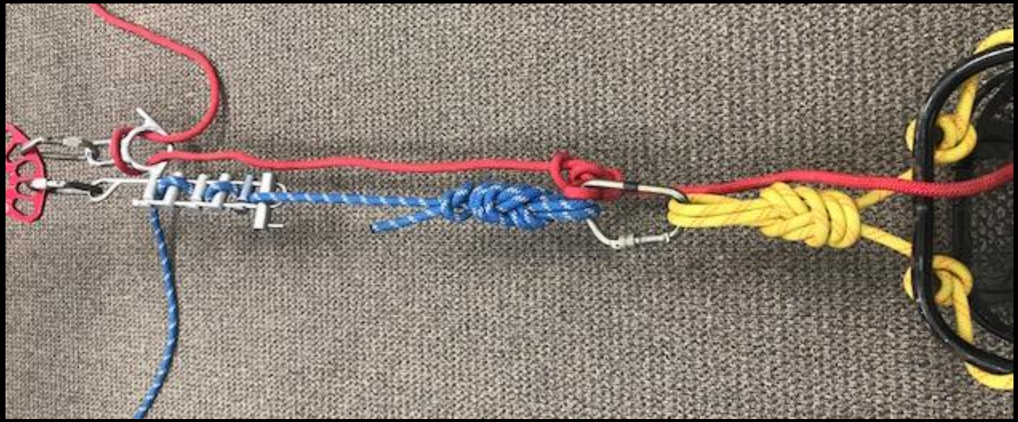


Lowering

- Decent Control Device located at anchor or Masterpoint

- Knot and/or Yoke located at load

- Allows rescuer the ability to operate hands free



Munter Hitch

- Not capable of controlling heavy loads
- Should **ONLY** be used with a one person load.
- Used to both give and take slack .
- Should be used with an extra large carabiner.
- Munter operator **MUST** keep both hands on the line at all times.
- Recommended for low angle operations **ONLY**.

Super Munter Hitch

- More capable of controlling heavy loads
- Should be used with a two person load.
- Used to both give and take slack .
- Should be used with an extra large carabiner.
- Munter operator MUST keep both hands on the line at all times.
- Recommended for low angle operations ONLY.

Tandem Prusik

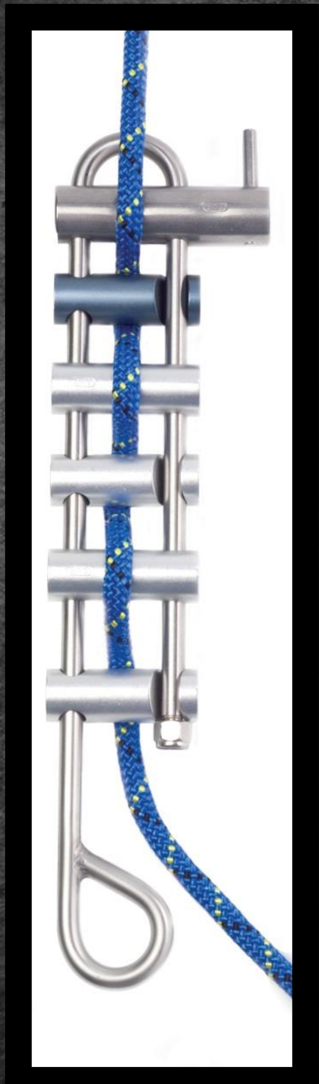
- Can be used for both one and two person loads.
- If a fall should occur the Prusik belay will catch the fall without operator assistance.
- Should Not be used as a High-Angle lowering system.
- Triple Wrap Tandem Prusik

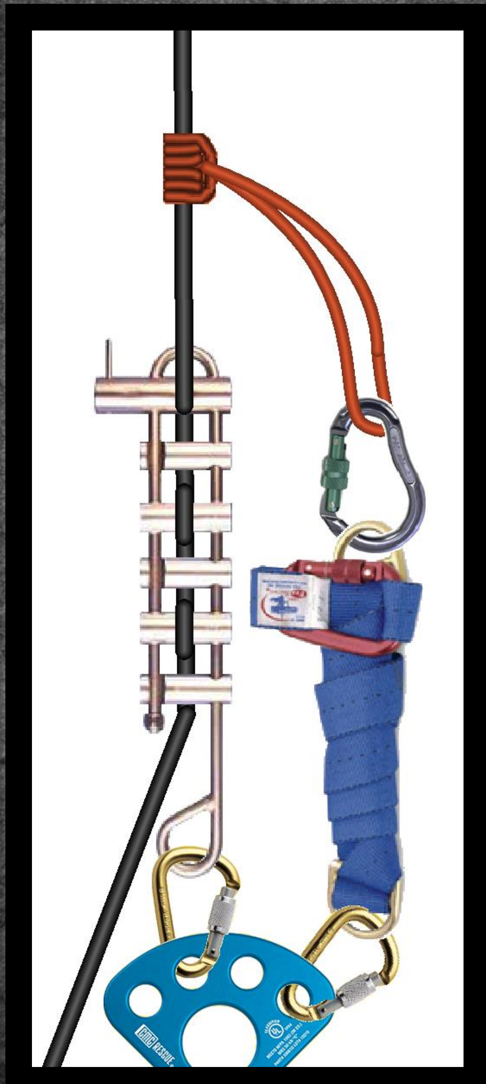
Figure 8 with Ears

Can be used for both one and two person loads.

If a fall should occur the operator must activate by “Braking”.

Brake Bar Rack





With Prusik Bypass

- Can be used for both one and two person loads.
- If a fall should occur the operator must activate by “Braking”.
- Should Not be used as a lowering system on anything vertical without prusik bypass. Will not pass a whistle test without it.

Safety Line Operation

Working Belay Line or Secondary

All safety line belay systems should have an anchor system completely separate from the main line anchor point!

Try to maintain a foot of "slack" in the line

Note: At a 30˚ angle or greater a 2 rope system is recommended.

Lowering Commands

- **Quiet!**
- Safety ready? – *Ready*
- Mainline ready & locked off? – *Ready (Locked off)*
- Rescuer ready? – *Ready*
- Load the line
- Transition the edge
- Lower
- Stop

Mechanical Advantages

Mechanical Advantage:

The amount of force that is required to move a load and is expressed in the terms of a ratio of output force to input force.

Input force = (Haul Side)
Output force = (Load Side)

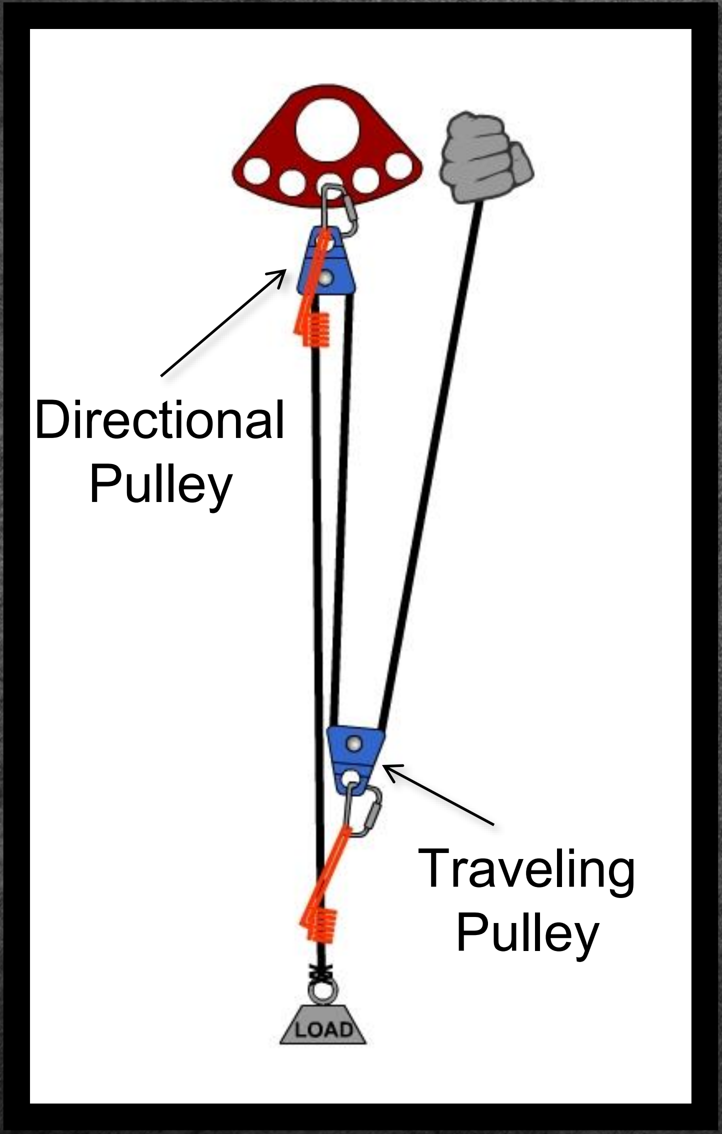
Mechanical Advantage is both a force divider and a multiplier

Haul Systems

General "Guidelines"

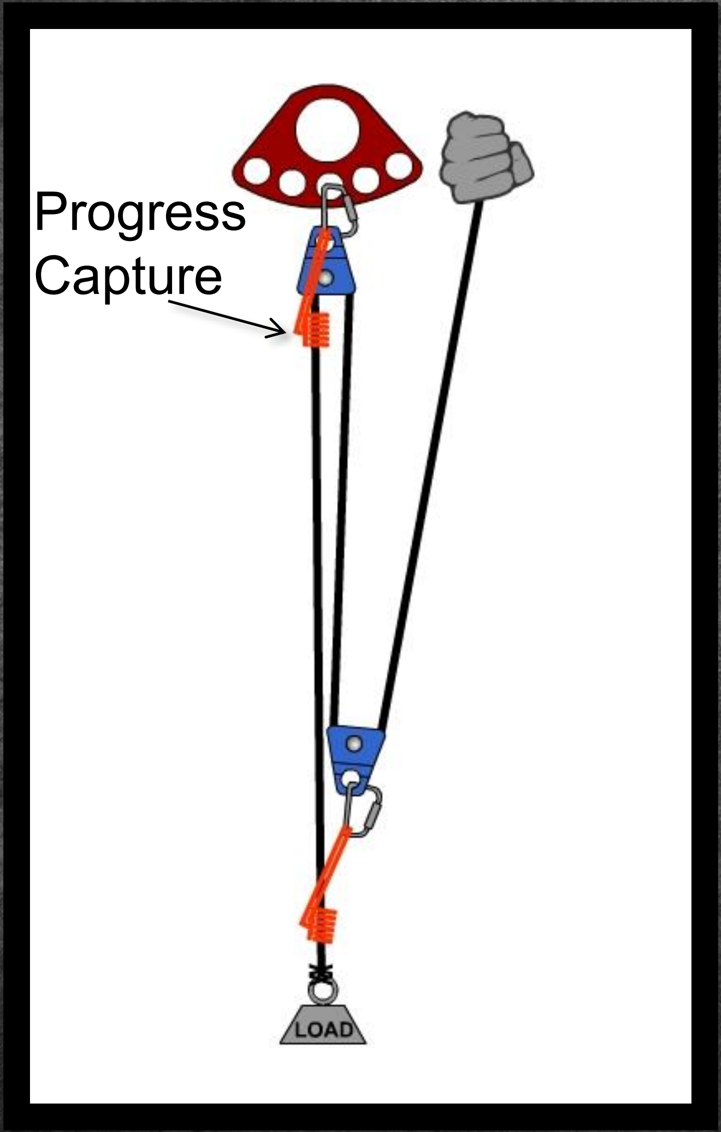
- Try to use no more than 5 pulleys for haul systems
- Recommend the use of a Prusik as haul cam
- Maximize your throw to Minimize Resets
- Smooth hauling
- Rule of 18 - Refers to the mechanical advantage of a system multiplied by the number of rescuers operating the system. The product of these numbers should be **18** or below to stay on the safe side.

Pulley Types



- Directional Pulley – Changes the direction of the rope (Usually attached to an anchor point)
- Traveling Pulley – Creates Mechanical Advantage

Progress Capture



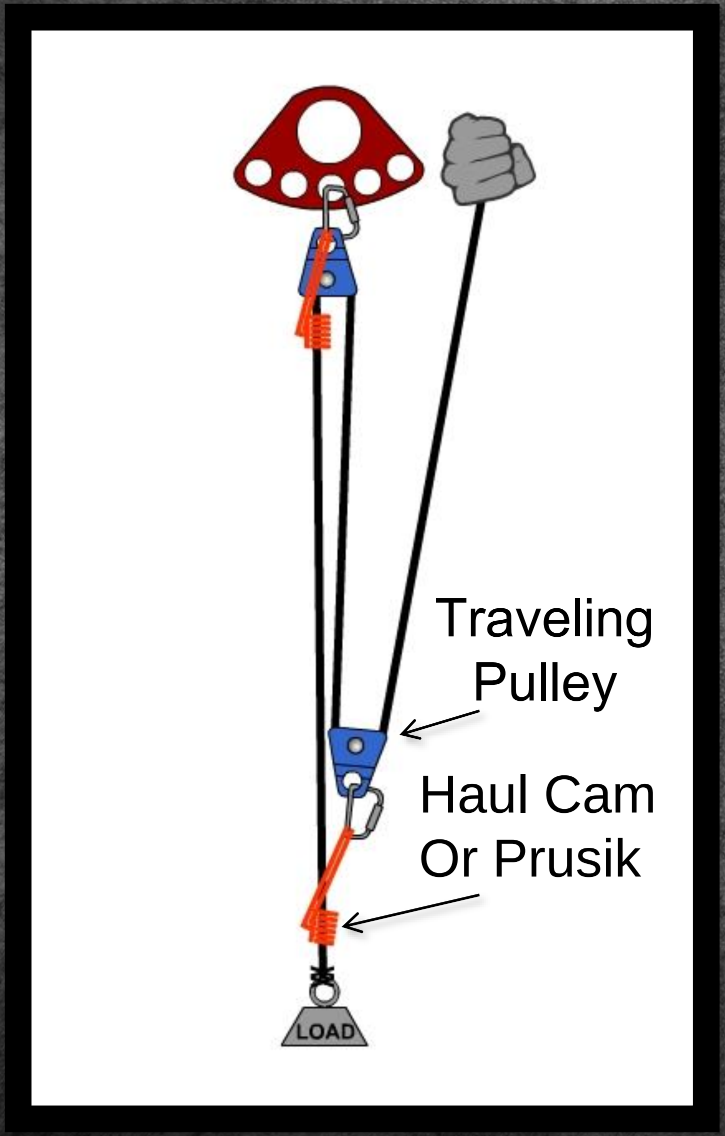
- Placed at the anchor pulley
- Used to hold the load if tension is relieved off the haul system
- Will allow the system to be reset if pulleys collapse together
- Also referred as Ratchet Cam
- Software Cam Example : Prusik
- Hardware Cam Examples: Rope Grab and/or Ascender

Prusik as Progress Capture

Light Use Performance Requirements
13.5kN (3,038 lbf) to double performance
Add a Tandem Prusik

- Travels and grabs well on dry ropes
- Should be used if there is a potential for a shock load.
- Can damage the rope mantle (sheath) at high forces
- Will creep around 1,000lbs and slip around 3,000lbs

Haul Cam or Haul Prusik

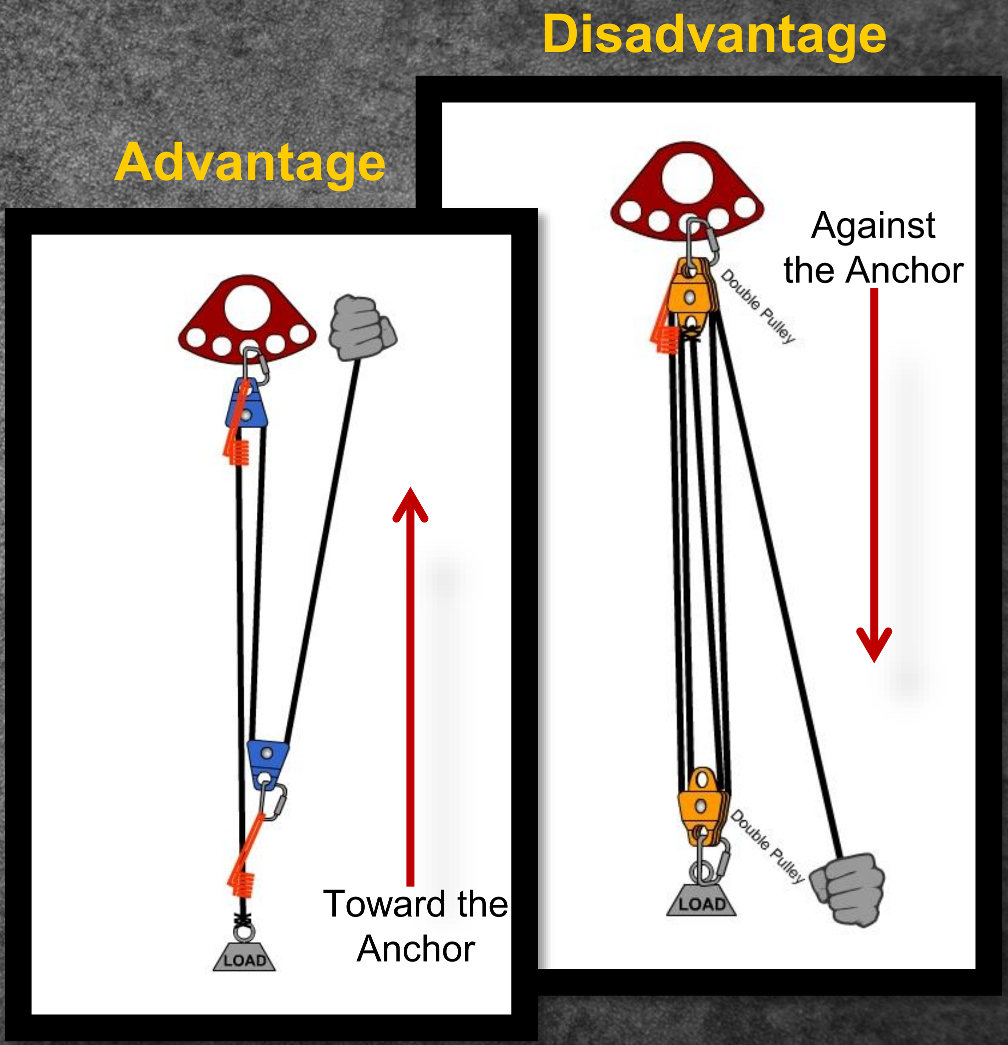


- Utilized to grab rope
- Software Cam Example : Prusik
- Hardware Cam Examples: Rope Grab and/or Ascender
- Travelling pulleys are attached to haul cams

Advantage vs. Disadvantage

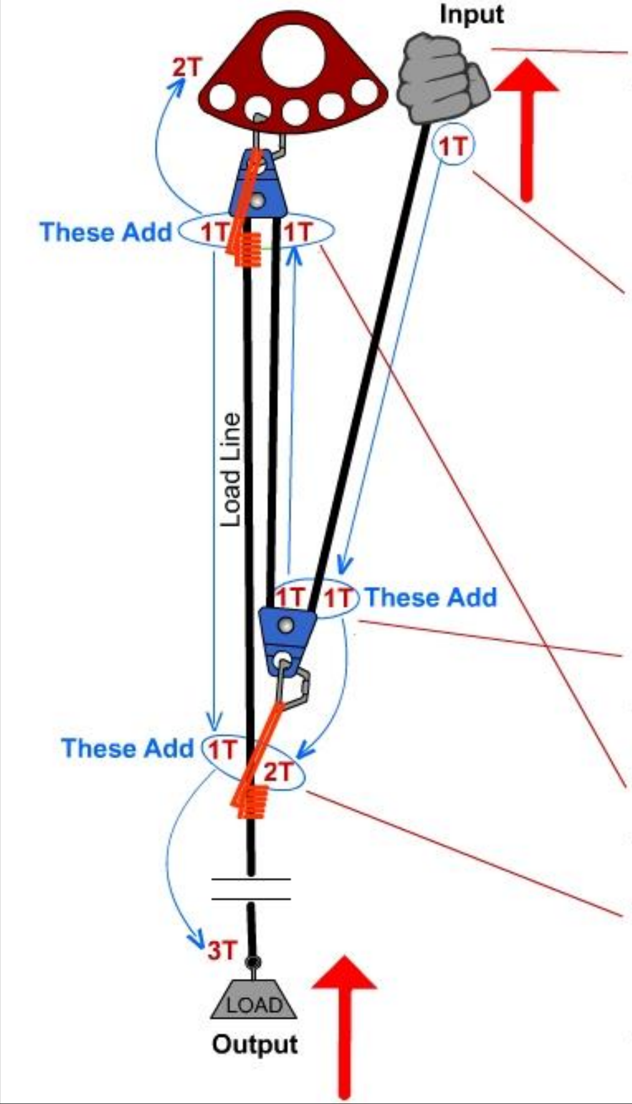
If you are pulling against the anchor, the system is rigged to disadvantage. This is because there are additional forces to the anchor due to the pulley principal.

If you are pulling toward the anchor, the system is rigged to advantage. Due to the lack of additional stress on the anchor due to the pulley principal.



Tension Analysis

TENSION ANALYSIS



Using this overly simplified "T method" we are applying theoretical force to the input side.

NOTE:
When calculating theoretical force, ALWAYS start from the input side!

In this example, we are starting with 1 unit of tention, we are calling this unit of tension "1T". 1T is where the hand is pulling up.

NOTE:
Pulley principle 1 states: Tension on one side of the pulley must be equal on the other side of the pulley.

Pulley principle 2 states: Those two tensions must add to the top of the pulley.

Following the pulley principle(s) there is 1T on each side of the pulley. These tensions add (1T+1T=2T) and are thrown to the Prusik grabbing the load line.

The 1T continues up towards the Pulley at the rigging plate. The same theory applies. The 1T+1T=2T gets added to the top of the pulley and adds to the rigging plate

The 1T then continues down to where the haul Prusik grabs the haul line (1T+2T=3T). Those forces combine 3T at the load.

There is 1T on the input and 3T on the output. This is a 3:1 Mechanical Advantage System with 2T on the anchor.

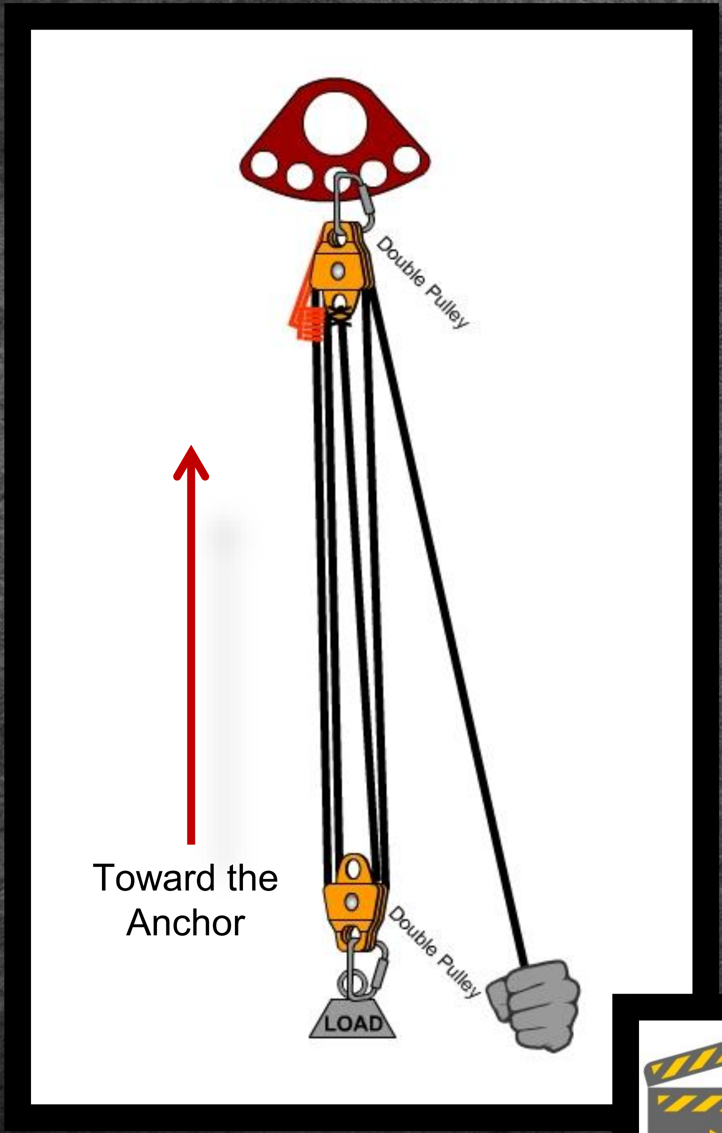
MA System Types

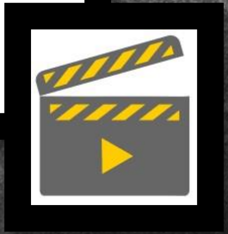
There are several Types of Mechanical Advantage System configurations. When a system is being built “on the fly” it is important to know which style system is being built. Understanding the basics (conceptually) will help identify what is needed to be constructed for a particular task. These are the 8 types of system configurations used in rope rescue:

- Simple Systems
- Compound Systems
- Complex Systems
- Piggy Backed Systems
- Ganged Systems
- Inside Systems
- Force Accumulation Systems
- RADS Systems

Simple Mechanical Advantage Systems

Simple MA Systems

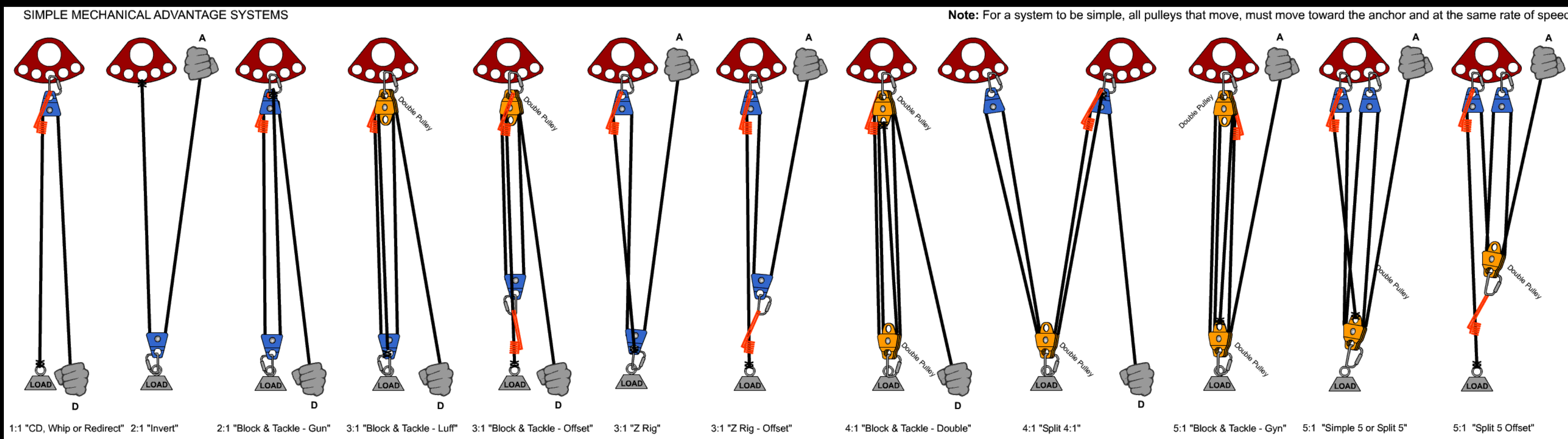




- For a system to be simple, all traveling pulleys move toward the anchor AND at the same rate of speed
- Calculate by “T” Method tension analysis

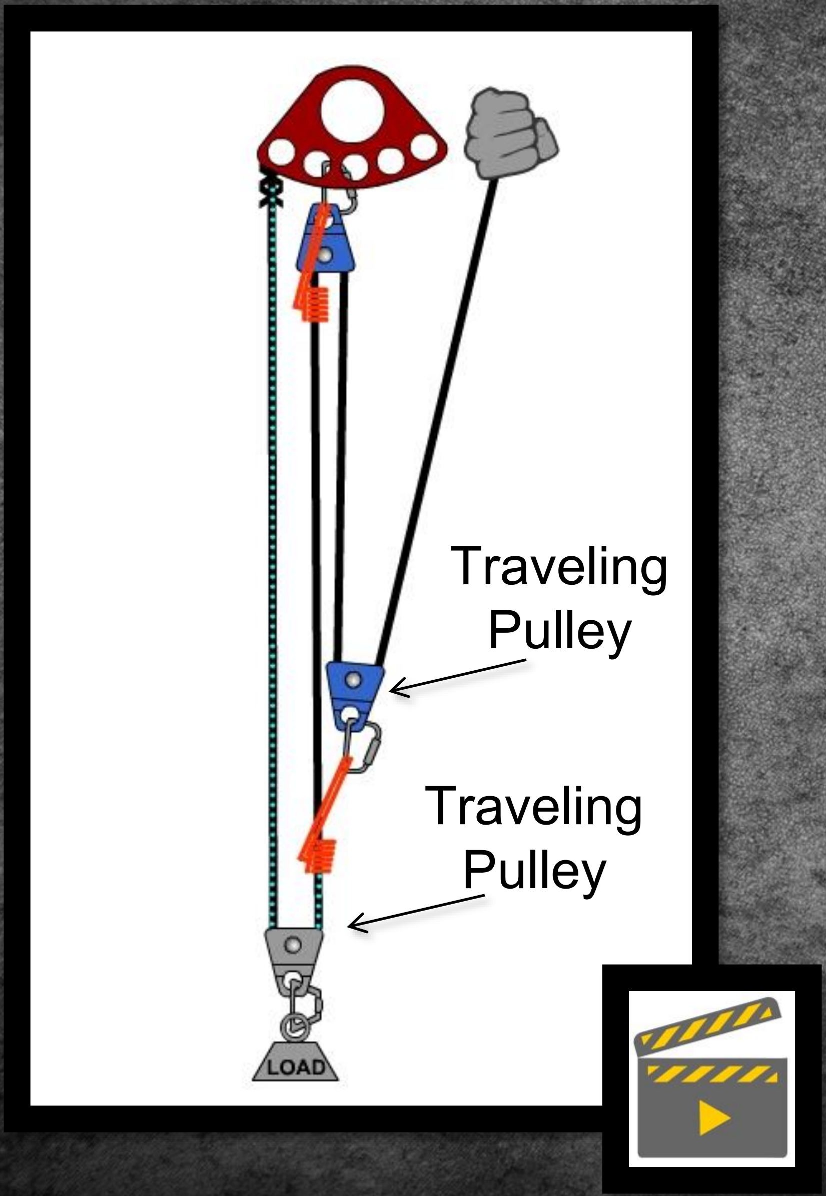
12 Simple MA Systems

These are the 12 most common Simple Mechanical Advantage Systems used in rope rescue.



Compound Mechanical Advantage Systems

Compound MA Systems



- For a system to be compound, a simple system pulling on another simple system

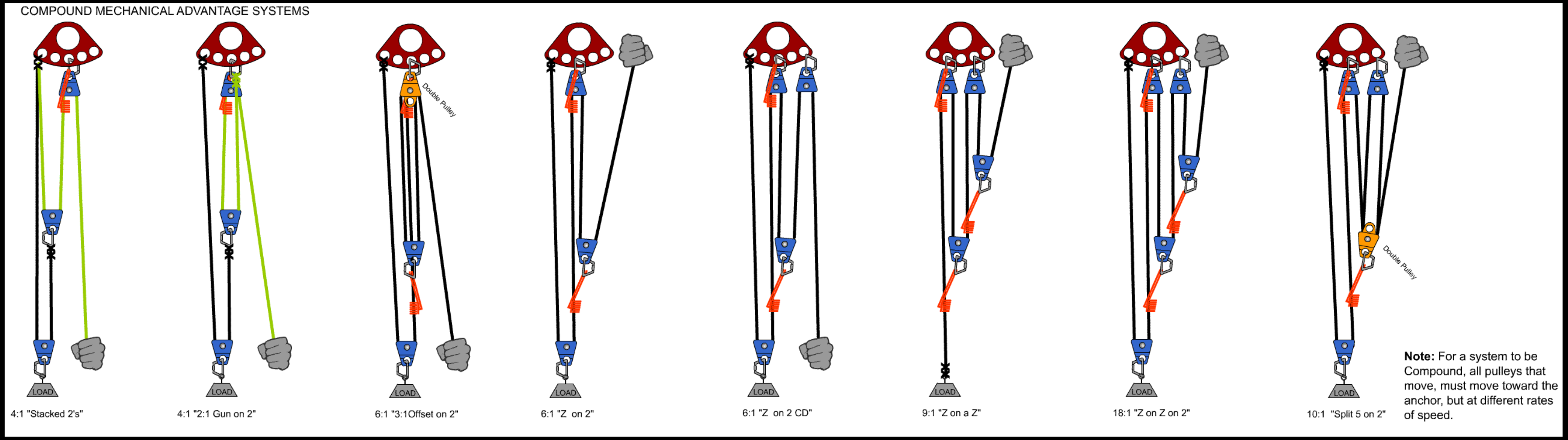
OR

- All traveling pulleys move toward the anchor but different rates of speed
- Calculate by multiplying the simple systems together or "T" Method
- Caveat: more resetting required

- Example:
- Black Rope = System 1
- Dotted Blue Rope = System 2

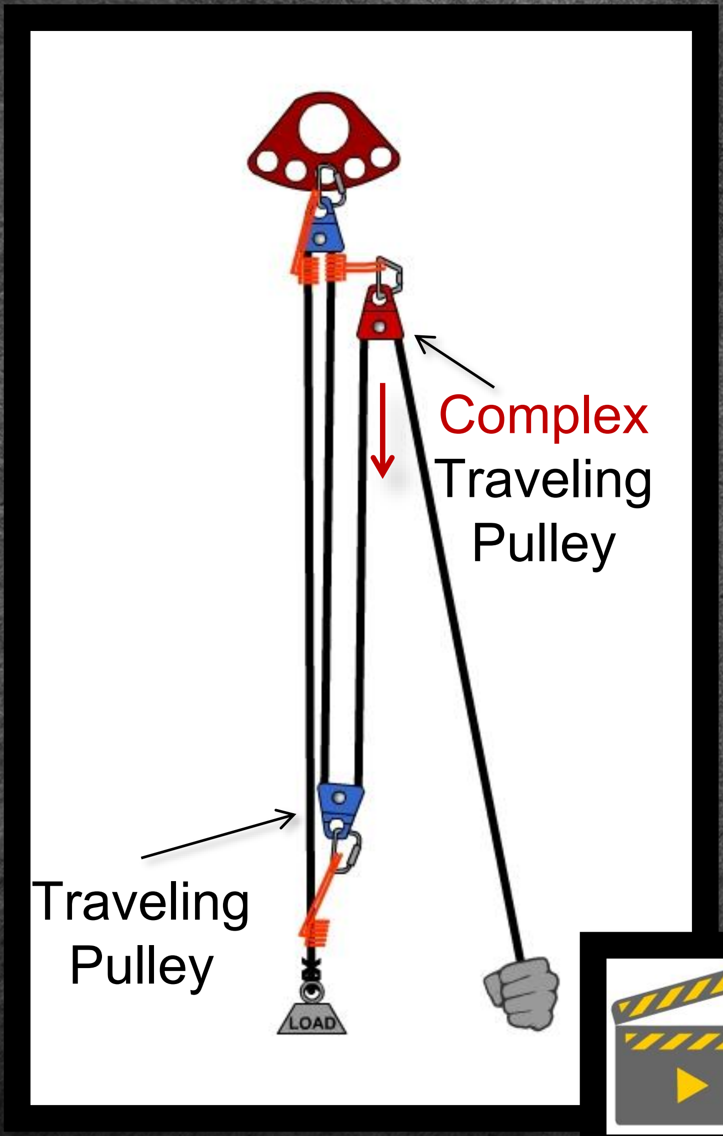
8 Compound MA Systems

These are the 8 most common Compound Mechanical Advantage Systems used in rope rescue.



Complex Mechanical Advantage Systems

Complex MA Systems



- At least one of the traveling pulleys move toward the load (Away from the Anchor)

OR

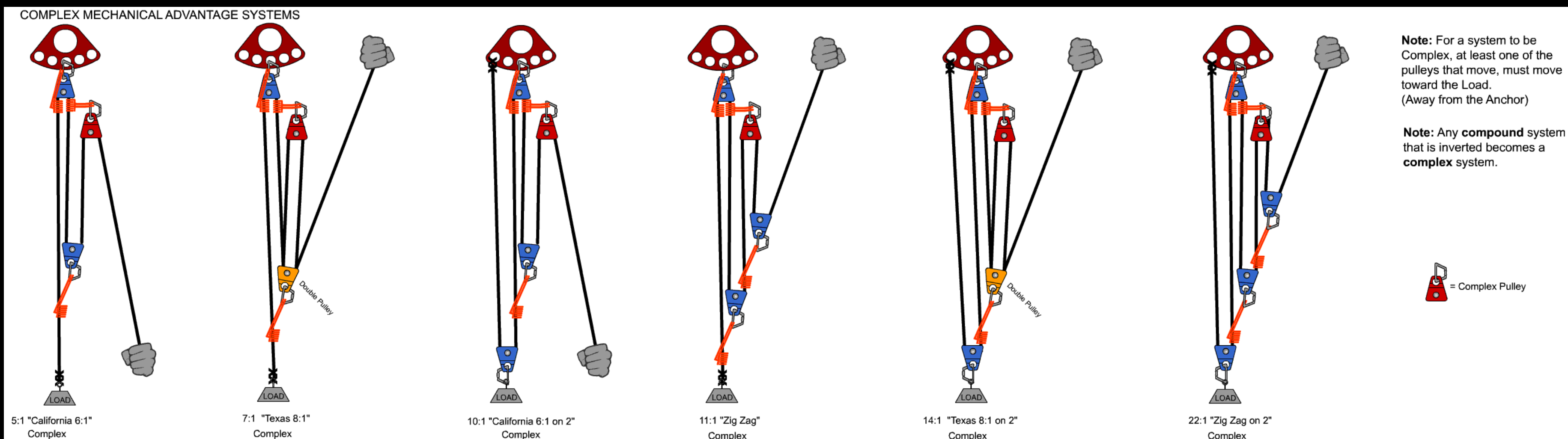
- Does not meet the requirements of the Simple or Compound systems

- Calculate by multiplying the simple systems together or “T” Method
- Caveat: more resetting required, needs a larger haul field

- Example:
- Red Pulley = Complex Pulley moving toward the load

6 Complex MA Systems

These are the 6 most common Complex Mechanical Advantage Systems used in rope rescue.



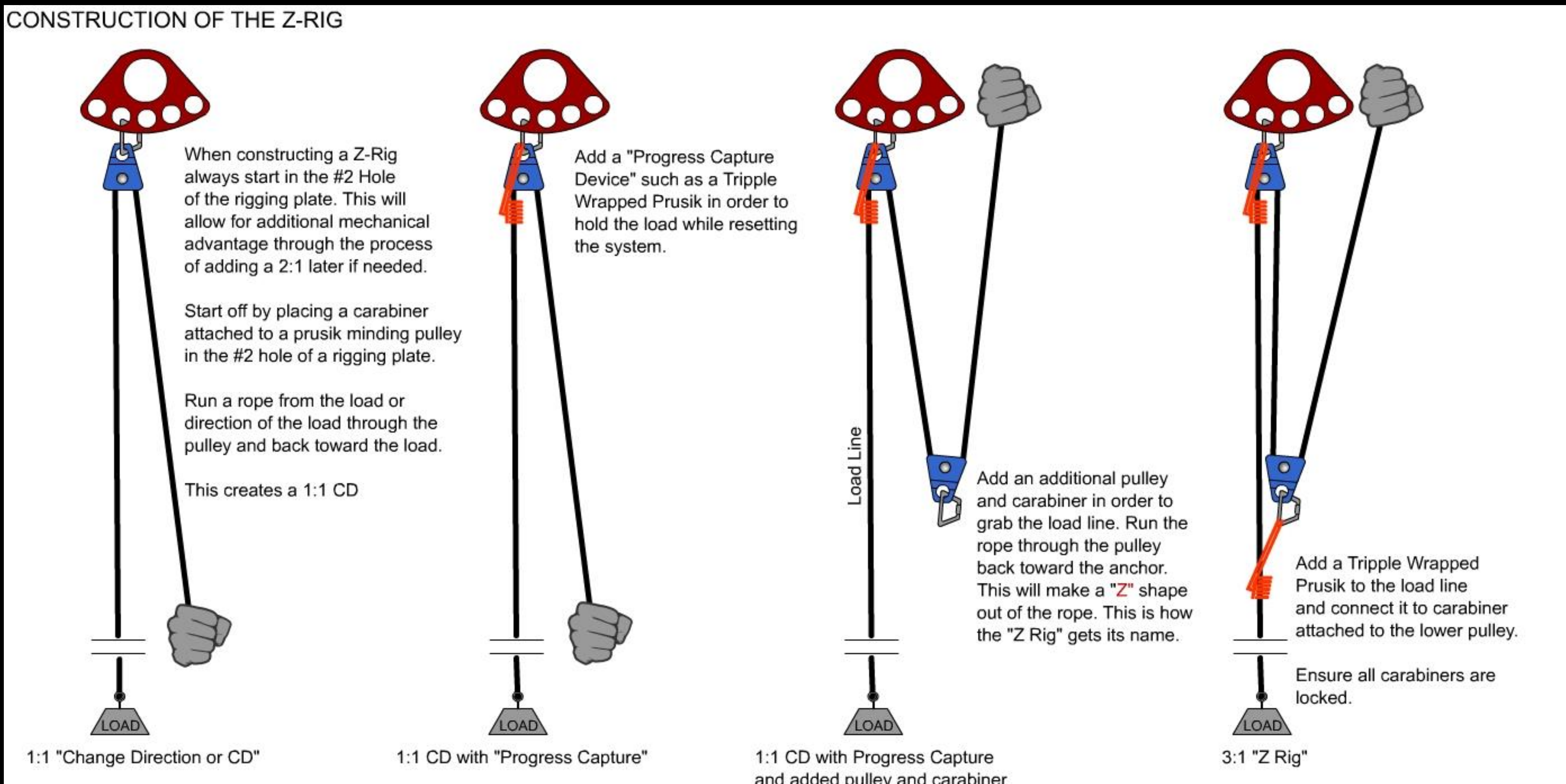
The Z-Rig

The 3:1 Z-Rig is one of the quintessential mechanical advantage system used by rescuers. This system when “offset” requires 1/3 of the rope than the 4:1 block and tackle system. It can be converted easily to a 6:1 compound by the addition of a single pulley (kick) and is a powerhouse due to its ability to be modified while loaded if progress capture is in place.

With a few modifications the Z-Rig can give a Rescue Team as much as a 22:1 Mechanical Advantage. The Z-Rig is reasonably easy to rig, is easy to add a progress capture device and provides an appropriate amount of mechanical advantage to raise one or two people.

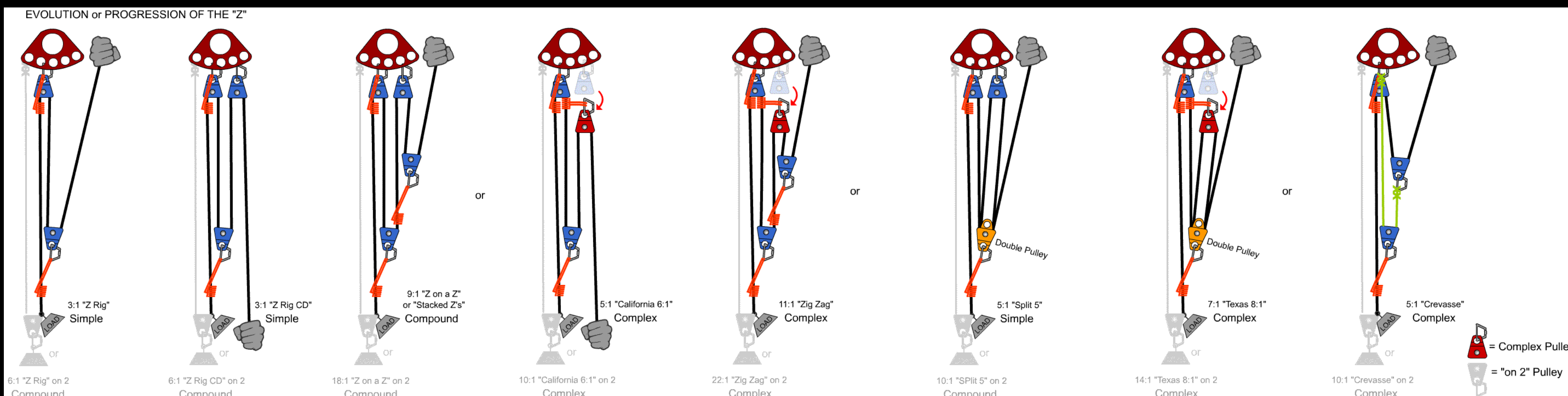
This system is paramount to a rescuer’s arsenal and will unlock true stroke advantage with minimal rope consumption while offering a multitude of benefits both vertically and horizontally.

Z-Rig Construction



Evolution of the Z-Rig

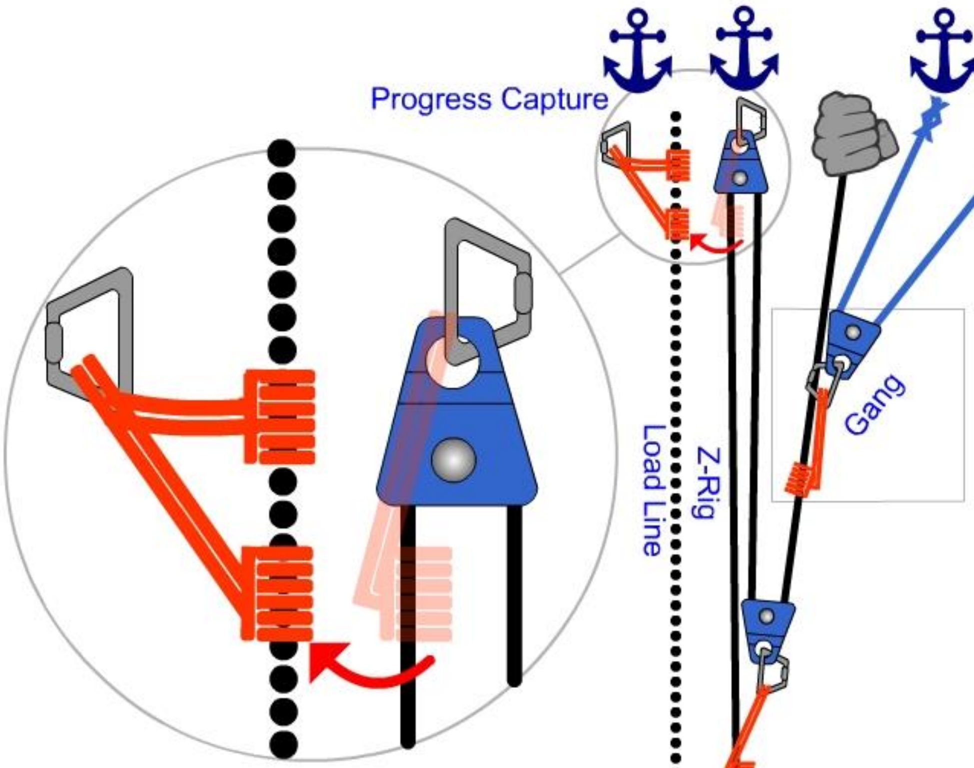
This shows the evolution or progression of the Z-Rig. By adding or changing a pulley or pulley's position, different systems are created.



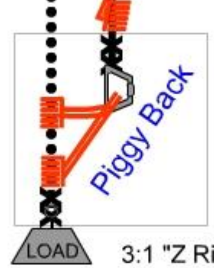
These systems could be Simple, Compound, Complex or Inside, depending on configuration.

Piggy Back & Gang Mechanical Advantage Systems

Piggy Back & Gang



Note: When adding a "Piggy Back" System to a Load Line, ensure a progress capture is on the Load Line (Tandem Tripple Wrapped Prusiks), and not on the MA System. This allows the MA system to be reset on the Load Line.



3:1 "Z Rig" Piggy Back with 2:1 Gang

Note: The addition of a "Gang" on a Haul System allows for more distance in a haul field OR additional Mechanical Advantage without additional rope consumption of the MA System's rope.

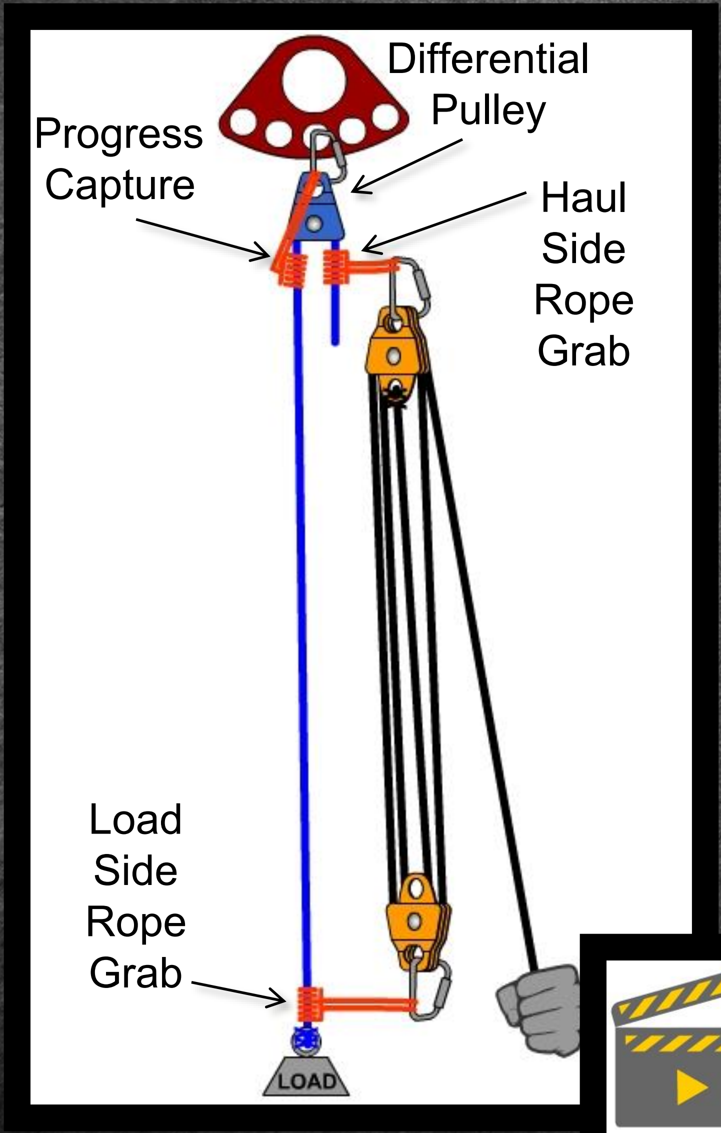
Note: The blue rope is a 2:1 Gang added to a 3:1 Z Rig. This creates a 6:1 MA on the Load Line.

Z Rig		2:1		
3:1	x	2:1	=	6:1

Note: Gang systems do not require Tandem Triple Wrapped Prusiks due to the force is greatly diminished on the back side of the MA System. A single Prusik (or rope grab/ascender) also allows for faster reset time and effeciency.

Inside Mechanical Advantage Systems

Inside MA Systems

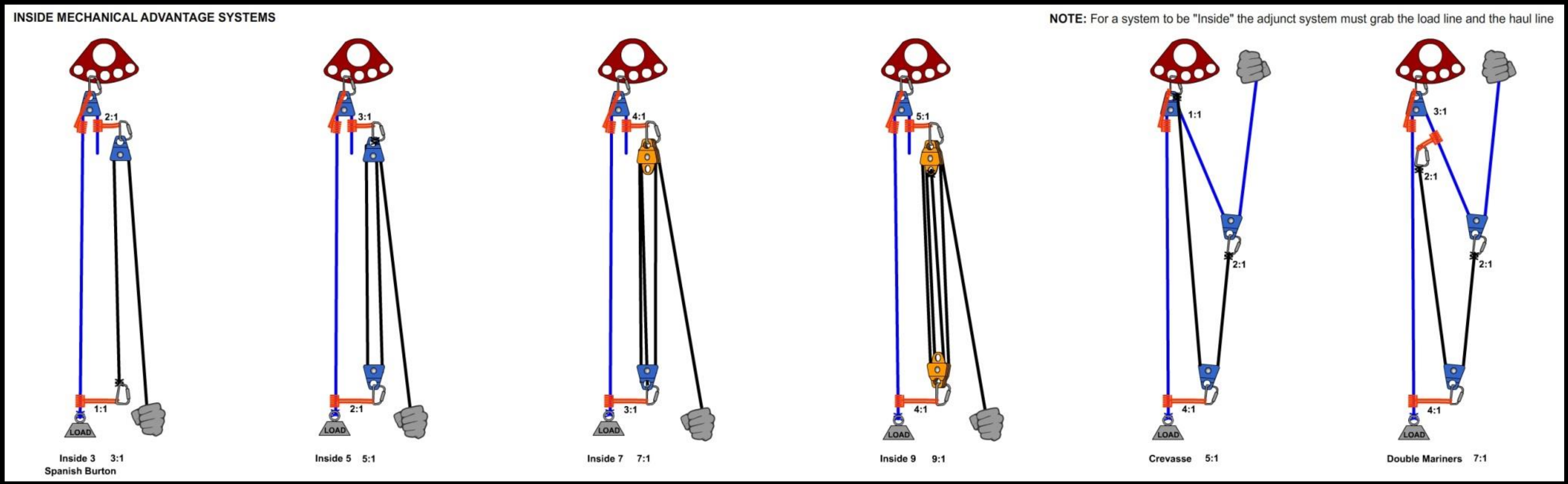


- An Inside Mechanical Advantage System is an adjunct system attached within a host rope system. Unlike a Piggy Back or Gang system, an Inside System attaches to both the Load side of the host rope and the Haul side of the host rope that is ran through a change direction pulley.

- Creates a complex system.
- The adjunct system (Compression System) is now acting on both sides of the Change Direction Pulley which changes the function to a Differential Pulley.
- Caveat: more resetting required

6 Inside MA Systems

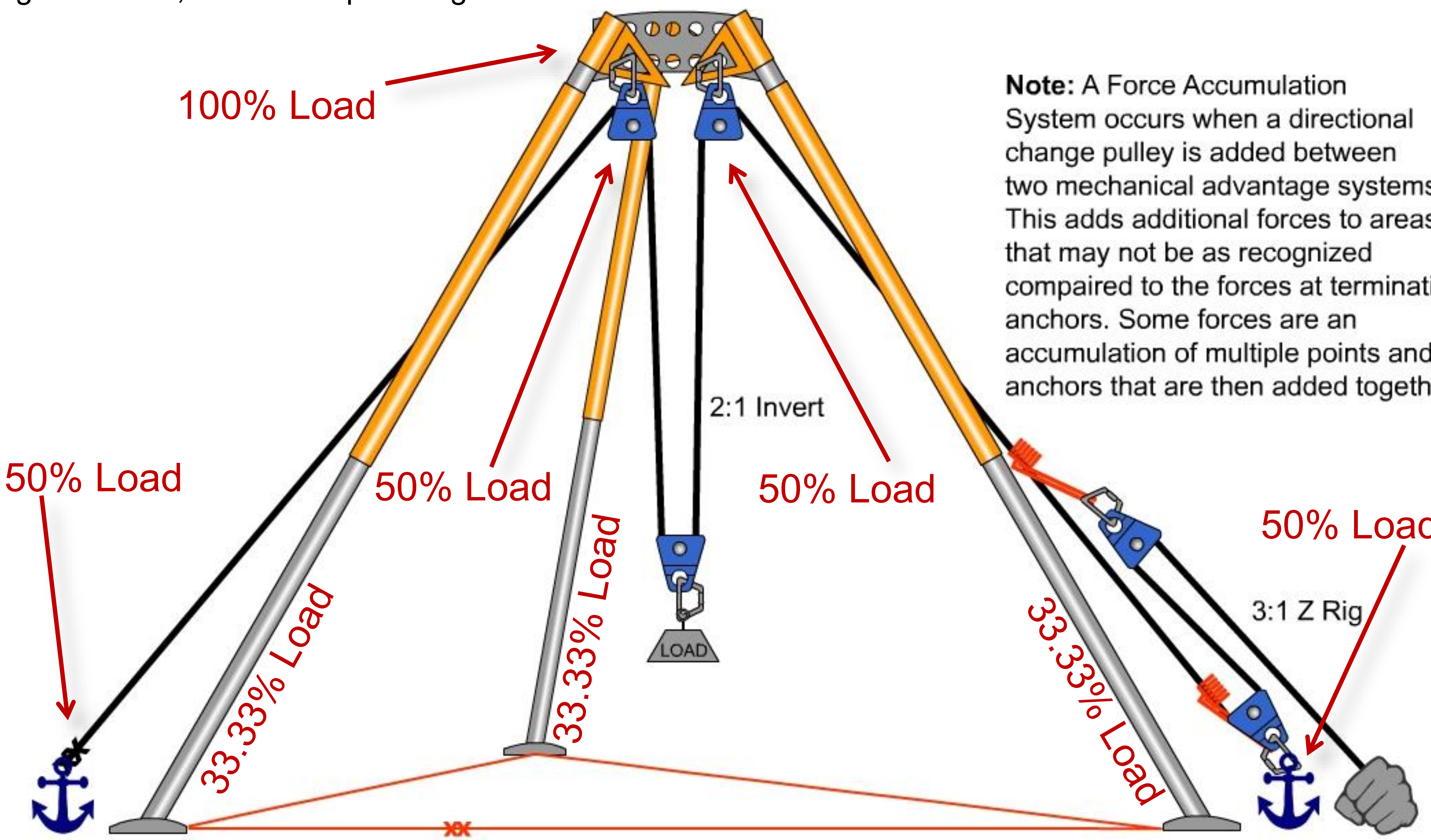
These are the most common Inside Mechanical Advantage Systems used in rope rescue.



Force Accumulation Mechanical Advantage Systems

Force Accumulation System

English Reeve, Confined Space Rig



Note: A Force Accumulation System occurs when a directional change pulley is added between two mechanical advantage systems. This adds additional forces to areas that may not be as recognized compaired to the forces at termination anchors. Some forces are an accumulation of multiple points and anchors that are then added together.

Compound Force Accumulation System Example: 6:1 " Z on 2"

RADS Effect Systems

RADS Effect

The RADS Effect is a force effect felt by the Anchor and a weight effect felt by the Hauler when the hauler becomes the load. RADS doubles the system effectiveness.

The pulley principal is then inverted reducing stress on the anchor to only the weight of the load. The load is now divided by the system line and the haul line

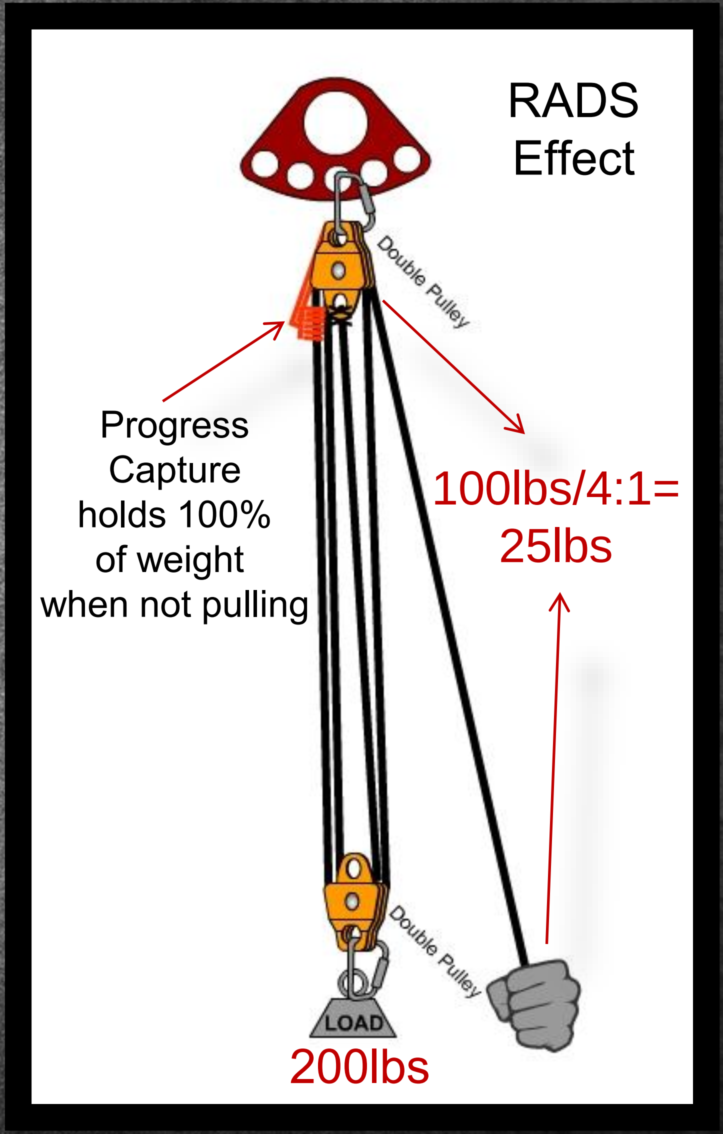
Example: 200lb load/2 = 100lbs

Due to MA system reduction (4:1 MA) the hauler would only be pulling 1/4 of 100 lbs.

100/4 = 25lbs or 4:1 with RADS = 8:1

Note: you may only RADS a system that is rigged to disadvantage.

Hauler is the Load



Hauling Commands

- **Quiet!**
- Safety ready? – *Ready*
- Main line ready? – *Ready*
- Haul team ready? – *Ready*
- Rescuer ready? – *Ready*
- Haul
- Stop
- Lock off (Shunt) and Reset

Patient Assessment

Patient Assessment

In all cases requiring emergency medical treatment, immediately call, or have a co-worker call to request emergency medical assistance.

Minor First Aid Treatment

First aid kits are stored in the Rescue Trailer. If an employee sustains an injury or are involved in an accident requiring minor first aid treatment, they shall:

- Inform their supervisor.
- Administer first aid treatment to the injury or wound.
- If a first aid kit is used, indicate usage on the accident investigation report.
- Access to a first aid kit is not intended to be a substitute for medical attention.
- Provide details for the completion of the accident investigation report.

Patient Assessment

Non-Emergency Medical Treatment

For non-emergency work-related injuries requiring professional medical assistance, management must first authorize treatment. If an employee sustains an injury requiring treatment other than first aid, they shall:

- Inform their supervisor.
- Proceed to the posted medical facility. The supervisor will assist with transportation, if necessary.
- Provide details for the completion of the accident investigation report.

Eye Wash Stations/Safety Showers shall be used in the event an employee accidentally spills or splashes injurious chemicals or liquids on their clothing or body. Employees shall notify their supervisor if they use the Eye Wash Station/Safety Shower.

Patient Assessment

Emergency Medical Treatment

If an employee sustains a severe injury requiring emergency treatment:

- Call for help and seek assistance from a co-worker.
- Use the emergency telephone numbers and instructions posted next to the telephone in your work area to request assistance and transportation to the local hospital emergency room.
- Provide details for the completion of the accident investigation report.

First Aid Training

Each employee will receive training and instructions on the following first aid procedures.

Patient Assessment

First Aid Procedures

WOUNDS:

Minor: Cuts, lacerations, abrasions, or punctures - Wash the wound using soap and water; rinse it well. Cover the wound using clean dressing.

Major: Large, deep and bleeding - Stop the bleeding by pressing directly on the wound, using a bandage or cloth. Keep pressure on the wound until medical help arrives.

BROKEN BONES:

Do not move the victim unless it is absolutely necessary.

If the victim must be moved, "splint" the injured area. Use a board, cardboard, or rolled newspaper as a splint.

BURNS:

Thermal (Heat) Rinse the burned area, without scrubbing it, and immerse it in cold water; do not use ice water. Blot dry the area and cover it using sterile gauze or a clean cloth.

Patient Assessment

CHEMICAL:
Flush the exposed area with cool water immediately for 15 to 20 minutes.

EYE INJURY:
Small particles - Do not rub your eyes. Use the corner of a soft clean cloth to draw particles out, or hold the eyelids open and flush the eyes continuously with water.

Large or stuck particles - If a particle is stuck in the eye, do not attempt to remove it. Cover both eyes with bandage.

Chemical - Immediately irrigate the eyes and under the eyelids, with water, for 30 minutes.

NECK AND SPINE INJURY:
If the victim appears to have injured his or her neck or spine, or is unable to move his or her arm or leg, do not attempt to move the victim unless it is absolutely necessary.

HEAT EXHAUSTION:
Loosen the victim's tight clothing. Give the victim "sips" of cool water. Make the victim lie down in a cooler place with the feet raised.

Patient Assessment

CPR (Cardiopulmonary Resuscitation)

Alternative names: Rescue breathing, chest compressions - for adults; resuscitation, cardiopulmonary - for adults

Definition: CPR is a combination of rescue breathing (which provides oxygen to the victim's lungs) and chest compressions (which keep the victim's heart circulating oxygenated blood).

Considerations: CPR can be lifesaving, but it is best performed by those who have been trained in a CPR course. The procedures described here are not a substitute for CPR training.

Time is very important when dealing with an unconscious who is not breathing. Death can occur in 8 to 10 minutes and brain death begins after 4 to 6 minutes without oxygen.

Causes: Cardiopulmonary arrest is a combination of 2 life-threatening conditions: absence of breathing and no heartbeat.

Patient Assessment

Symptoms:

- No Breathing
- No pulse
- Unconsciousness

NOTE: DO NOT give chest compressions if there is a heartbeat; doing so may cause the heart to stop beating.

NOTE: DO NOT move the victim's head or neck to check for breathing if a spinal injury is suspected.

Call immediately for emergency medical assistance:

- If you are not alone, have one person call the local emergency number while another person begins CPR.
- If you are alone, shout for help and administer CPR.

Patient Assessment

First Aid:

1. Check for consciousness. Shake or tap the victim gently. See if the victim moves or makes a noise. Shout, "Are you OK?"
2. If there is no response, shout for help.
3. Position the victim on his or her back on a hard surface, keeping the back in a straight line, supporting the head and neck. Unfasten the victim's clothing if necessary to gain access to the victim's chest.
4. Kneel next to the victim's chin. Tilt the head back and lift the jaw forward to move the tongue away from the windpipe. If a spinal injury suspected, pull the jaw forward without moving the head or neck. Don't let the victim's mouth close.
5. Place your ear close to the victim's mouth and watch for chest movement. For 5 seconds, look, listen, and feel for breathing.
6. If the victim is not breathing, begin rescue breathing. Maintain the head position, close the victim's nostrils by pinching them with your thumb and index finger, and cover the victim's mouth tightly with your mouth. Give 2 slow, full breaths, with a pause in between.

Patient Assessment

7. If the chest does not rise, reposition the head and give 2 more breaths. If the chest still doesn't rise, the victim's airway is blocked. Follow these instructions for chocking:

Chocking Symptoms:

- Unconscious
- Lack of breathing
- Inability to move air into the lungs with mouth-to-mouth resuscitation

NOTE: DO NOT try to grasp an object that is lodged in the victim's throat. This might push it farther down the airway. If the object is visible in the mouth, it may be removed.

NOTE: DO NOT begin the chest compressions of CPR (if heartbeat has stopped) until the airway is cleared.

Patient Assessment

Basic Airway Management:

a. Roll the victim onto their back on a hard surface, keeping their back in a straight line, firmly supporting their head and neck. Expose the victim's chest.

b. Open the victim's mouth with your thumb and index finger, placing your thumb over his tongue and your index finger under his chin. If the object is visible and loose, remove it.

c. Lift the victim's chin while tilting the head back to move the tongue away from the windpipe. If a spinal injury is suspected, pull the jaw forward without moving the head or neck. Don't let the mouth close.

d. If the victim is not breathing, begin rescue breathing. Maintain the head position, close the victim's nostrils by pinching them with your thumb and index finger, and cover the victim's mouth tightly with your mouth. Give 2 slow, full breaths, with a pause in between.

e. If the victim's chest does not rise, reposition the head and give 2 more breaths.

f. If the victim's chest still doesn't rise, begin abdominal thrusts, as follows. Kneel at the victim's feet or astride the thighs (or to the side if the victim is obese or pregnant). Place the heel of your hand in the middle of the abdomen just above the navel, well below the tip of their breastbone. (If the victim is obese or pregnant, place the heel of your hand in the middle of the victim's breastbone. Do not place your hand on the ribs or on the tip of the breastbone.) Place your other hand on top of the first hand.

Patient Assessment

g. Give 6 to 10 quick thrusts compressing the victim's chest about 2 inches, pressing your hands inward and upward. Do not press to either side. Each thrust is a separate attempt to clear the victim's airway by forcing air out through the windpipe.
h. Open the victim's mouth with your thumb and index finger. If the object is visible and loose, remove it. Observe the victim's breathing. If the infant stops breathing, begin CPR.
i. If the object is not dislodged, give 2 breaths, 6 to 10 abdominal thrusts, and then check for the object. Repeat this sequence until the object is dislodged or help arrives.

Patient Assessment

8. If the victim's chest does rise, place 2 fingers on the victim's Adam's apple. Slide your fingers into the groove between the Adam's apple and the muscle on the side of their neck to feel for a pulse for 5 to 10 seconds.
9. If the victim has a pulse, give 1 breath every 5 seconds. Check the pulse after every 12 breaths.
10. Be sure the local emergency number has been called. Have someone else make the call if possible. Continue giving breaths and checking the pulse.
11. If the victim has no pulse, begin chest compressions. Maintain the head position and place the heel of your hand 2 finger-widths above the lowest notch of the victim's breastbone (where the lower edge of the ribcage meets in the middle). Place the heel of your other hand directly over the heel of the first hand. Interlock your fingers; don't let them touch the victim's chest. Lock your elbows straight. Lean your shoulders over your hands, and firmly press down about 2 inches into the victim's chest. Repeat the compressions 30-times. Give the compressions in a smooth, rhythmic manner, keeping your hands on the victim's chest. Don't rock back and forth - push straight down. Don't pause between compressions.

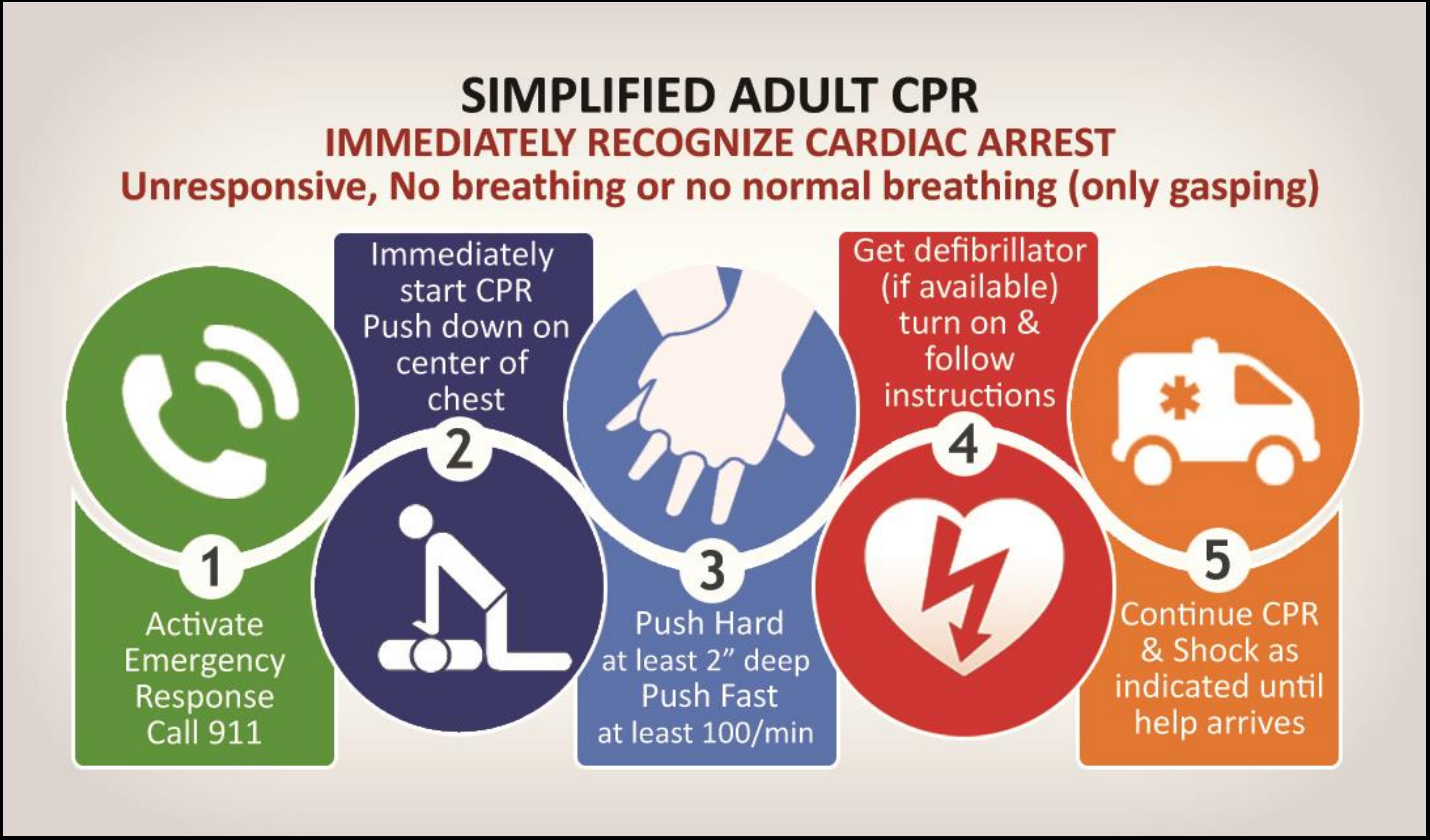
Patient Assessment

12. Give the victim 2-breaths, followed by 30-chest compressions. Repeat this sequence 4 times. Count aloud as you pump in a regular rhythm. You should pump at a rate of about 100-times a minute. Count 1 and 2 and 3 and 4 and... 30 and (breathe, breathe).
13. Recheck the victim's pulse for 5 to 10 seconds.
14. Repeat steps 12 and 13 until the victim's pulse resumes or help arrives. If the pulse resumes, go to step 9.
15. Once pulse and respiration resume, roll the person onto his side taking care to move the body as a whole unit. This is called the recovery position, but it should not be used if you suspect there might be a neck or spinal injury. Stay by the person until help arrives.

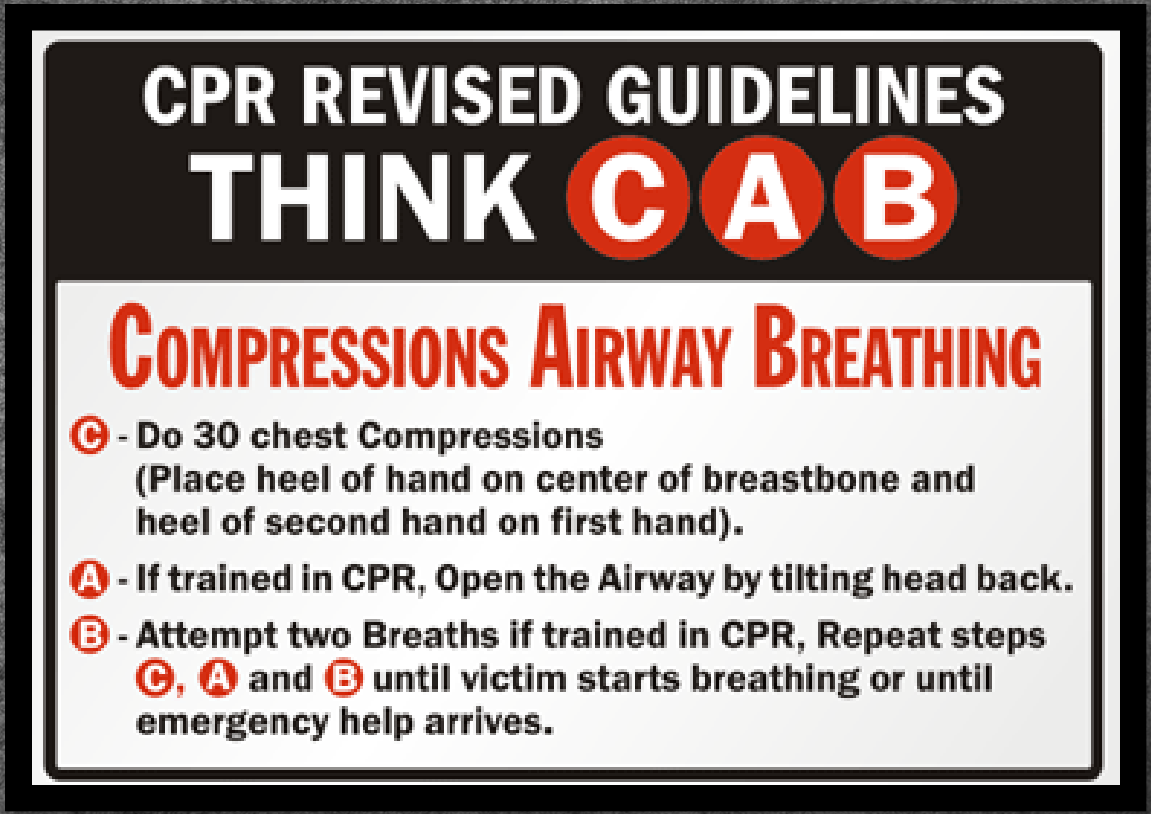
Patient Assessment

1. FEEL FOR CAROTID PULSE. KEEP PULSE CHECKS TO 10 SECONDS OR LESS
2. IF NO PULSE OR IF UNSURE A PULSE IS FELT, BEGIN CPR
3. PLACE HEEL OF HAND ON LOWER HALF OF STERNUM (BREASTBONE)
4. PLACE OTHER HAND ON TOP AND INTERLOCK FINGERS
5. KEEP ARMS STRAIGHT AND PRESS DOWN, COMPRESSING THE CHEST 2 INCHES
6. LET THE CHEST COMPLETELY RECOIL BETWEEN COMPRESSIONS
7. GIVE 30 COMPRESSIONS AT A RATE OF AT LEAST 100 PER MINUTE
8. OPEN AIRWAY WITH HEAD-TILT, CHIN-LIFT
9. GIVE 1 BREATH OVER 1 SECOND, THEN GIVE THE SECOND BREATH
10. RESUME CHEST COMPRESSIONS

Patient Assessment



Patient Assessment



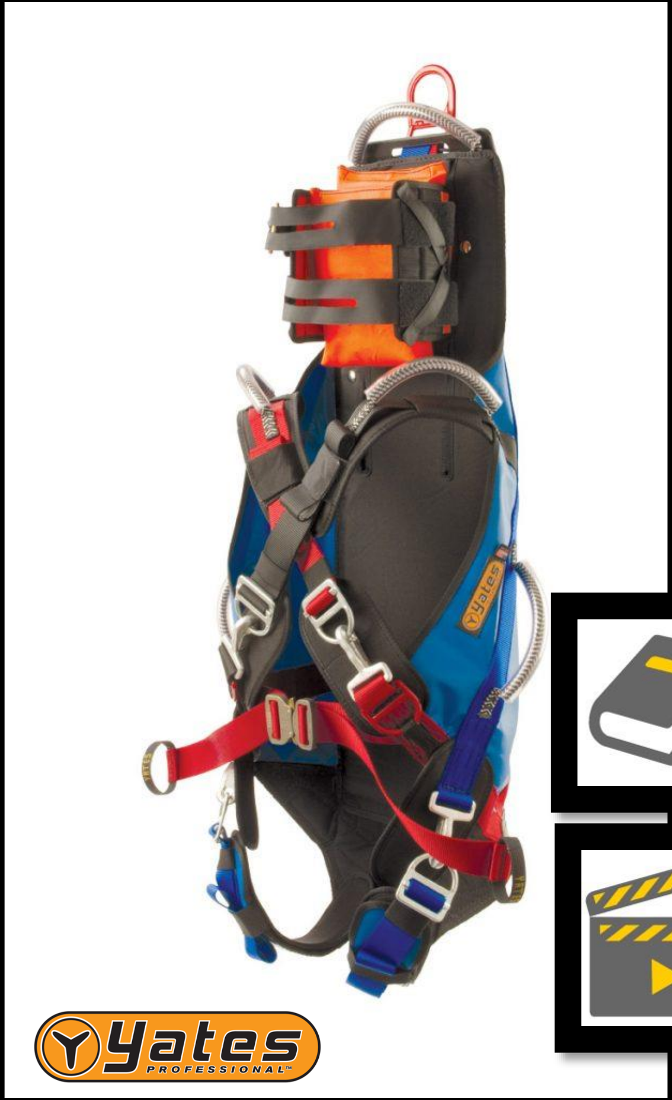
Packaging Systems

Patient Packaging

The process of securing a victim in a transfer device, with regard to existing and potential injuries or illness, so as to prevent further harm during movement.

Yates Spec Pak

- Patient packaging and extrication system that combines the backboard immobilization of a short board with the suspension and support of a full body harness.
- Extremely useful for any confined space operation where a vertical environment is encountered.
- Patient can be lifted vertically from D ring located at top of backboard.
- It must be used in conjunction with proper spinal immobilization such as the use of a cervical collar where conditions and protocols dictate.
- Color coded straps make application quick and easy
- Fits from small children to large adults



SKED Stretcher

- Immobilize spine and neck injuries and lift patients out of tight spaces
- Used to drag patients on multiple terrains
- Has a load capacity over 1,350 lbs
- Highly resistant to acids and alkali, and unable to be penetrated by liquids
- Vertical and horizontal lift capabilities
- Transport the patient through narrow openings
- Drag the patient when personnel are limited

Reeves™ Sleeve

- Immobilize spine and neck injuries and lift patients out of tight spaces
- Used to drag patients on multiple terrains
- Has a load capacity over 1,000 lbs
- Highly resistant to acids and alkali, and unable to be penetrated by liquids
- Vertical lift point and horizontal lift points
- Transport the patient through narrow openings
- Drag the patient when personnel are limited
- Removable Velcro head-securing blocks
- Adjustable head- and chin-securing straps
- Five chest and leg straps and a "fail-safe" strap

Long Spine Board

Backboard

- Immobilize spine and neck injuries and lift patients out of tight spaces
- Has a load capacity over 1,000 lbs
- Highly resistant to acids and alkali, and unable to be penetrated by liquids
- Vertical and horizontal lift points
- Transport the patient through narrow openings
- Should be placed in a Stokes Litter or SKED Litter prior to lowering

Scoop Stretcher

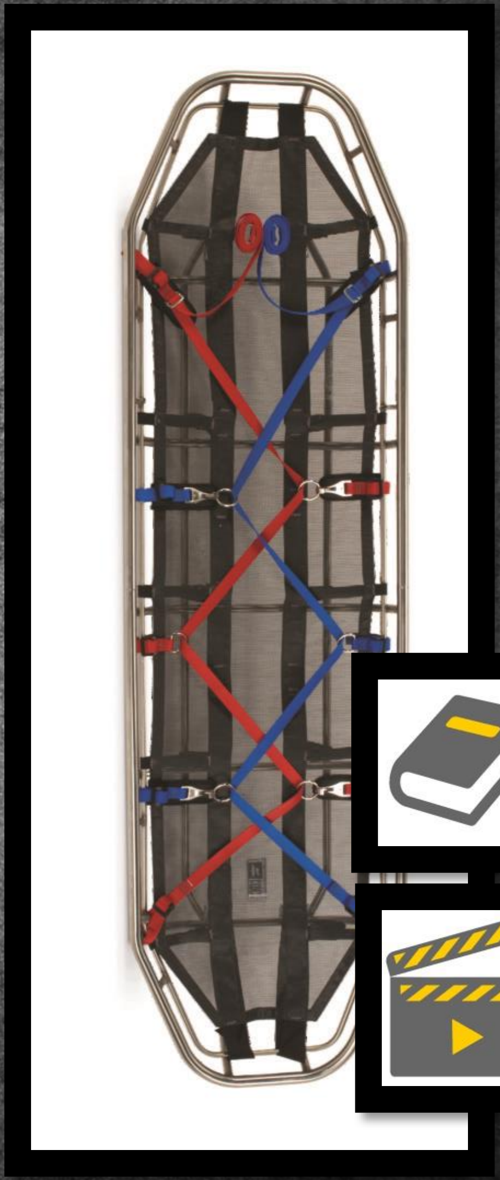
- Used to lift people who may have a spinal cord injury from the ground, either due to unconsciousness or in order to maintain stability in the case of trauma.
- Has a structure that can be split vertically into two parts, with shaped 'blades' towards the center which can be brought together underneath a patient.
- Reduce the chance of movement of injured areas during transfer of a trauma patient,
- More comfortable than a long spine board for transport

Universal Head Immobilizer

- The Universal Head Immobilizer is simple to use, light weight and easy to clean.
- It comes with two plastic-coated, closed-cell foam head supports
- A universal attachment base, and two durable head straps.
- The base plate fits all Ferno backboards (except the NAJO Sports Board).
- Head supports can be used on standard backboards, or turned around for use on the Ferno Scoop Stretcher.

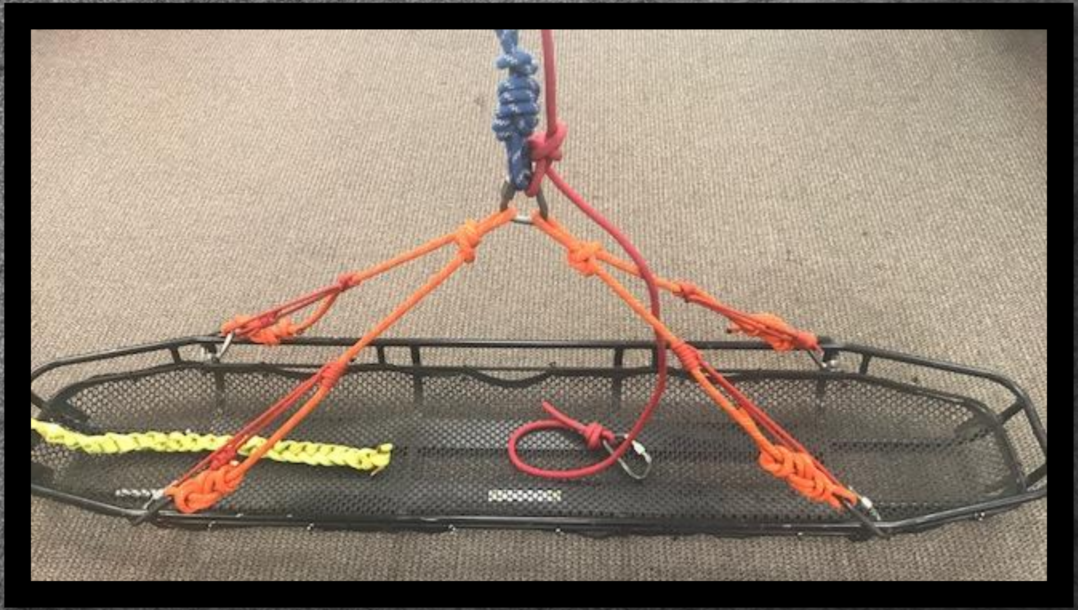
Stokes Litter

- Designed to be used where there are obstacles to movement or other hazards: for example, in confined spaces, on slopes, in wooded terrain.
- Shaped to accommodate an adult in a face up position and it is used in search and rescue operations.
- The patient is strapped into the basket, making safe evacuation possible.
- The patient generally is further protected by a cervical collar and sometimes a long spine board, so as to immobilize the patient and prevent further injury.



Horizontal Bridle

- **Litter Configuration** – Horizontal Stokes Litter
- **Rescue Package Connection** - Double Figure 8 on a Bight with Butterfly and Scaffold for patient
- **Yoke** - Delta Link
- **Bridle** – Rope & Prusik
- Only 1 Tag line needed

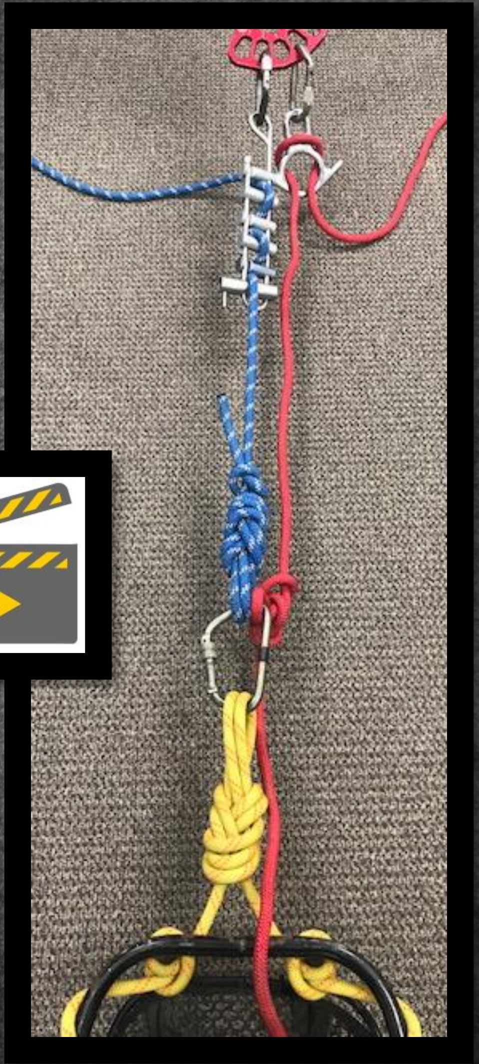


Arizona - IPS Quad-Bridle

- **Litter Configuration** – Horizontal Stokes Litter
- **Rescue Package Connection** – Doubled Long Tail Bowlines
- **Yoke** - Doubled Long Tail Bowlines
- **Bridle** – Rope & Prusik
- No Tag Line needed

Vertical Bridle

- **Litter Configuration** – Vertical
- **Rescue Package Connection** - Double Figure 8 on a Bight with Butterfly and Scaffold for patient
- **Yoke** – XL Carabiner
- **Bridle** – ¾ Clove Wrap
  - 2 mirrored Clove Hitches
  - 2 wrap, 3 wrap, 4 wrap
  - Square Knot with Safety
- 2 Tag lines recommended



Pick and Pivot System

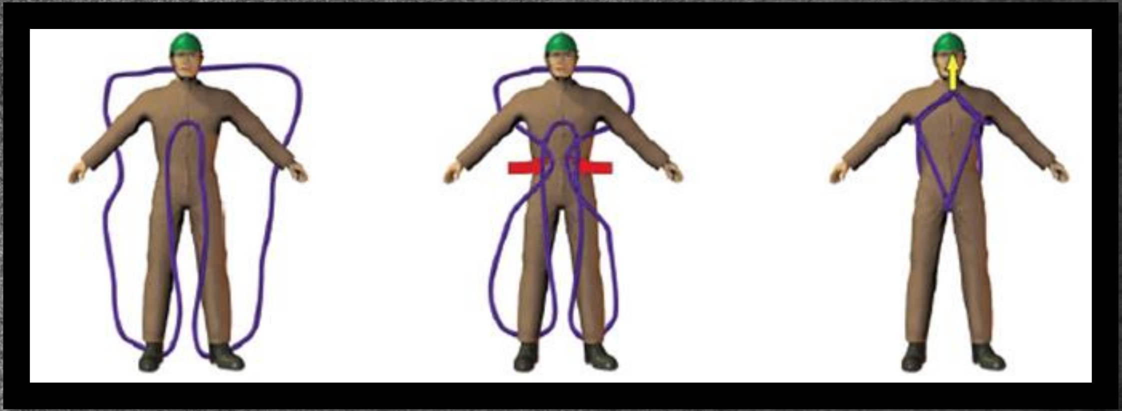
- **Litter Configuration** – Vertical
- **Rescue Package Connection** - Double Figure 8 on a Bight with Butterfly and Scaffold for patient
- **Yoke** – XL Carabiner
- **Bridle** – ¾ Clove Wrap
  - 2 mirrored Clove Hitches
  - 2 wrap, 3 wrap, 4 wrap
  - Square Knot with Safety
- Pick and Pivot can become the Tag line

Victim Harness

- Improvised harness constructed out of 1 inch tubular webbing

- Requires - 20 Foot section of webbing tied in a loop using a water knot

- Use caution to prevent patient from rolling out



Russia Victim Harness

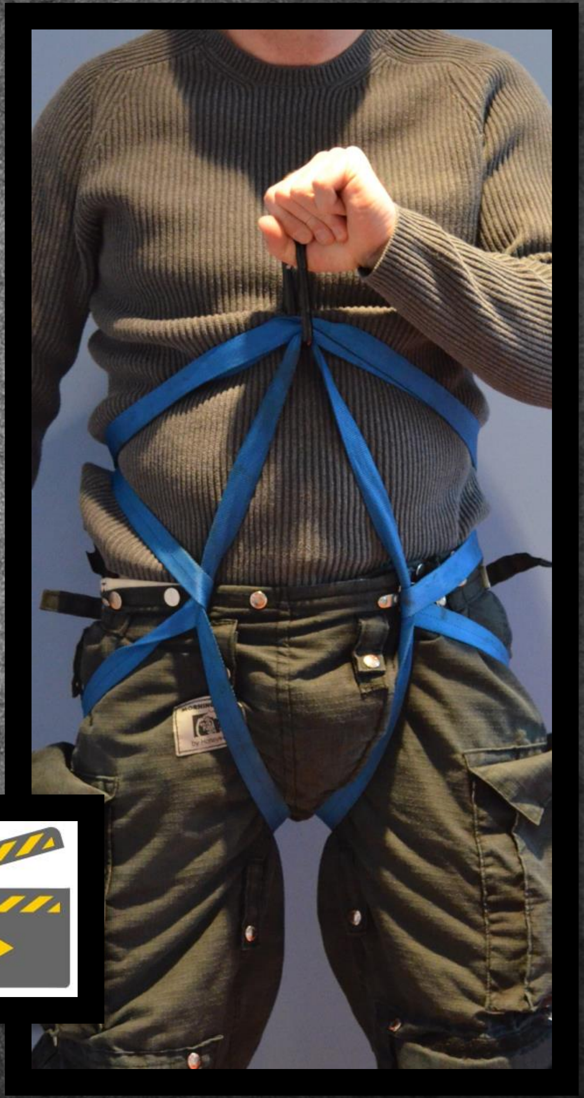
- Improvised harness constructed out of ½ inch Kernmantle Rope

- Requires - 15 Foot section of rope tied in 3 loops using a water knot

- Use caution to prevent patient from rolling out

Hasty Harness

- Improvised harness constructed out of 1 inch tubular webbing
- Requires - 20 Foot section of webbing tied in a loop using a water knot
- Use caution to prevent patient from rolling out

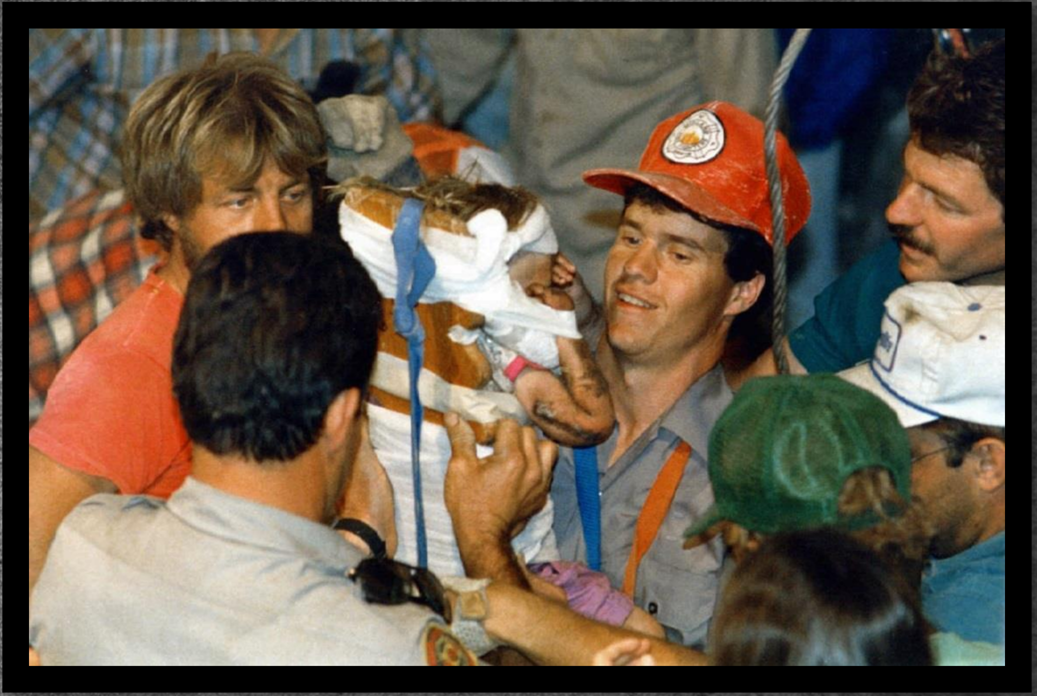


The Golden Hour

Medical professionals consider the 60-minute period following an injury or illness to be the "Golden Hour". Their goal is to provide the patient with treatment within this time period.

Our goal is to give medical staff as much time as possible to treat the patient within the first 60-Minutes.

An "average" elevated, confined space rescue in the industrial arena should not take longer than 15-minutes



1987 - "Baby Jessica," at 18 months old, fell down a 22-foot well in her aunt's backyard in Midland TX.

She remained trapped in the well for 58 hours.

Typical Rescue Response Times

0 – 3 minutes (3 min. duration)

- Permit-Required Confined Space incident occurs and rescue team is called

3 – 13 minutes (10 min. duration)

- Rescue Team Arrives at the Scene

13 – 23 minutes (10 min. duration)

- Rescue Team Sizes up and Prepares to initiate rescue

23 – 38 minutes (15 min. duration)

- Rescue team reaches and rescues patient

38 – 53 minutes (15 min. duration)

- Patient is transported and arrives at emergency room

Offsets

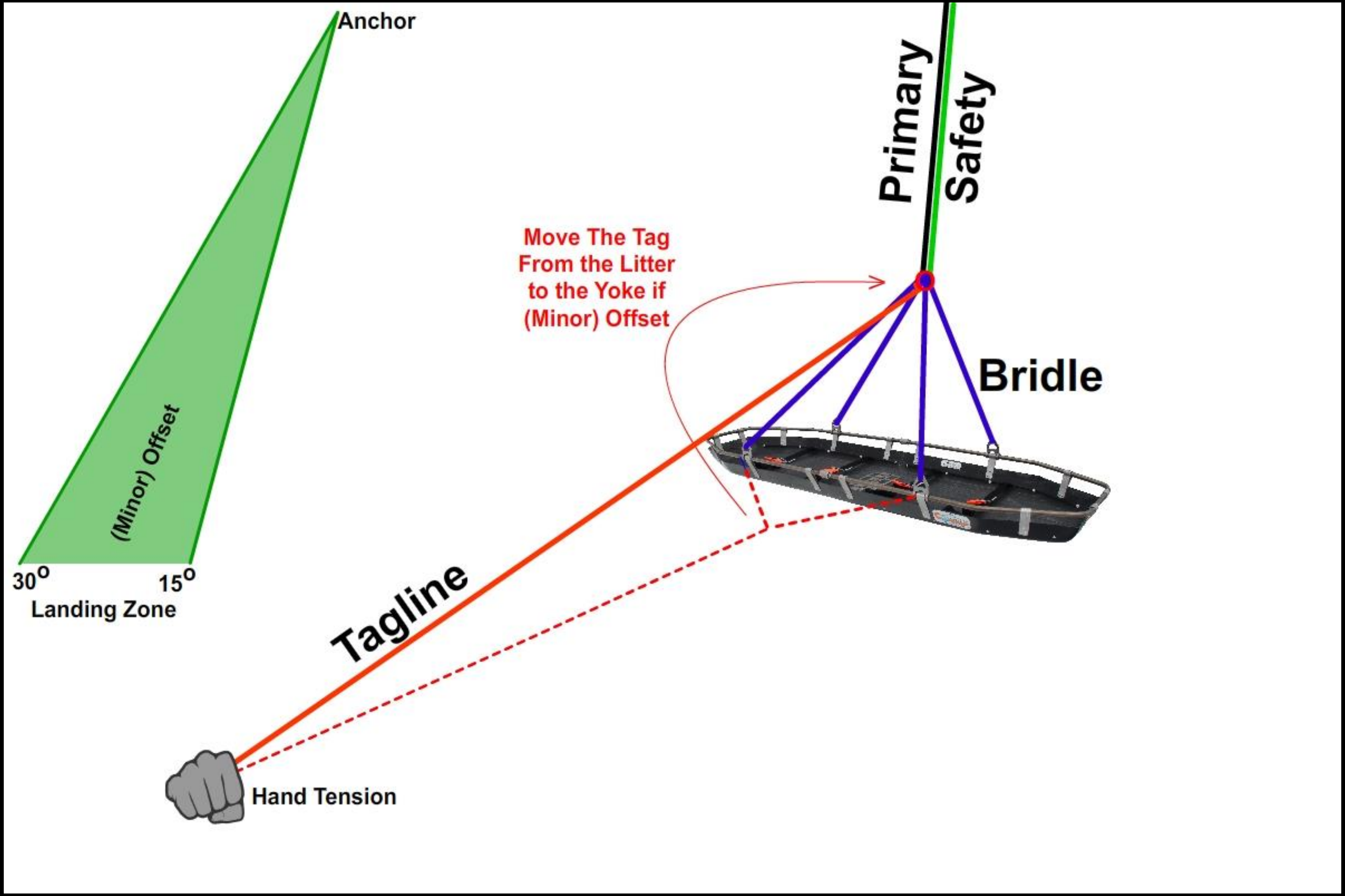
Offsets

Offset: A rope system that allows realignment of the proposed path, or orientation of a rescue package or individual. The two types are (Minor) Offsets and (Major) Offsets.

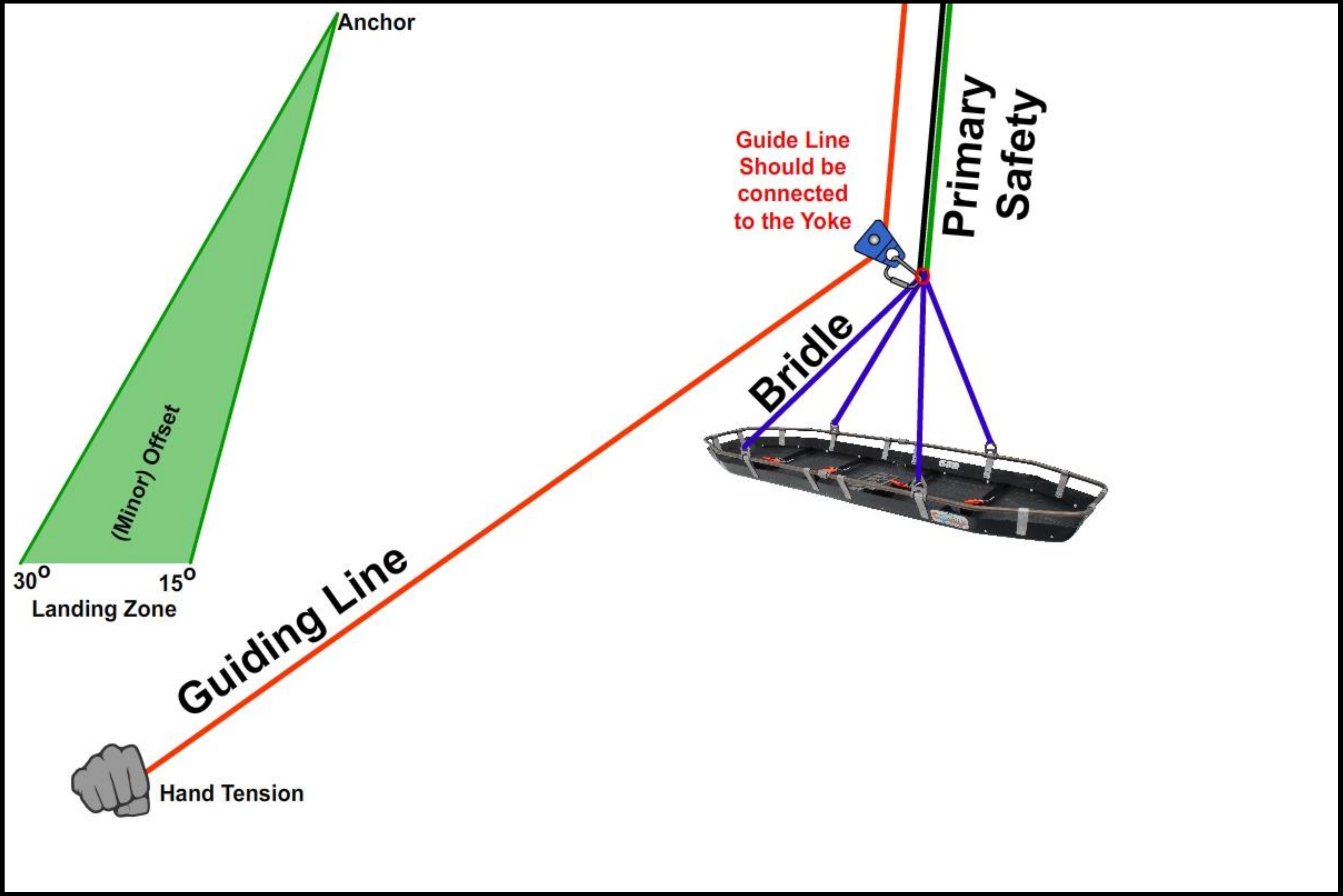
(Minor) Offsets

(Minor) Offset: A hand held adjunct rope system that allows realignment of the proposed path. These include the Tag Line and the Guiding Line.

Tag Line - (Minor)



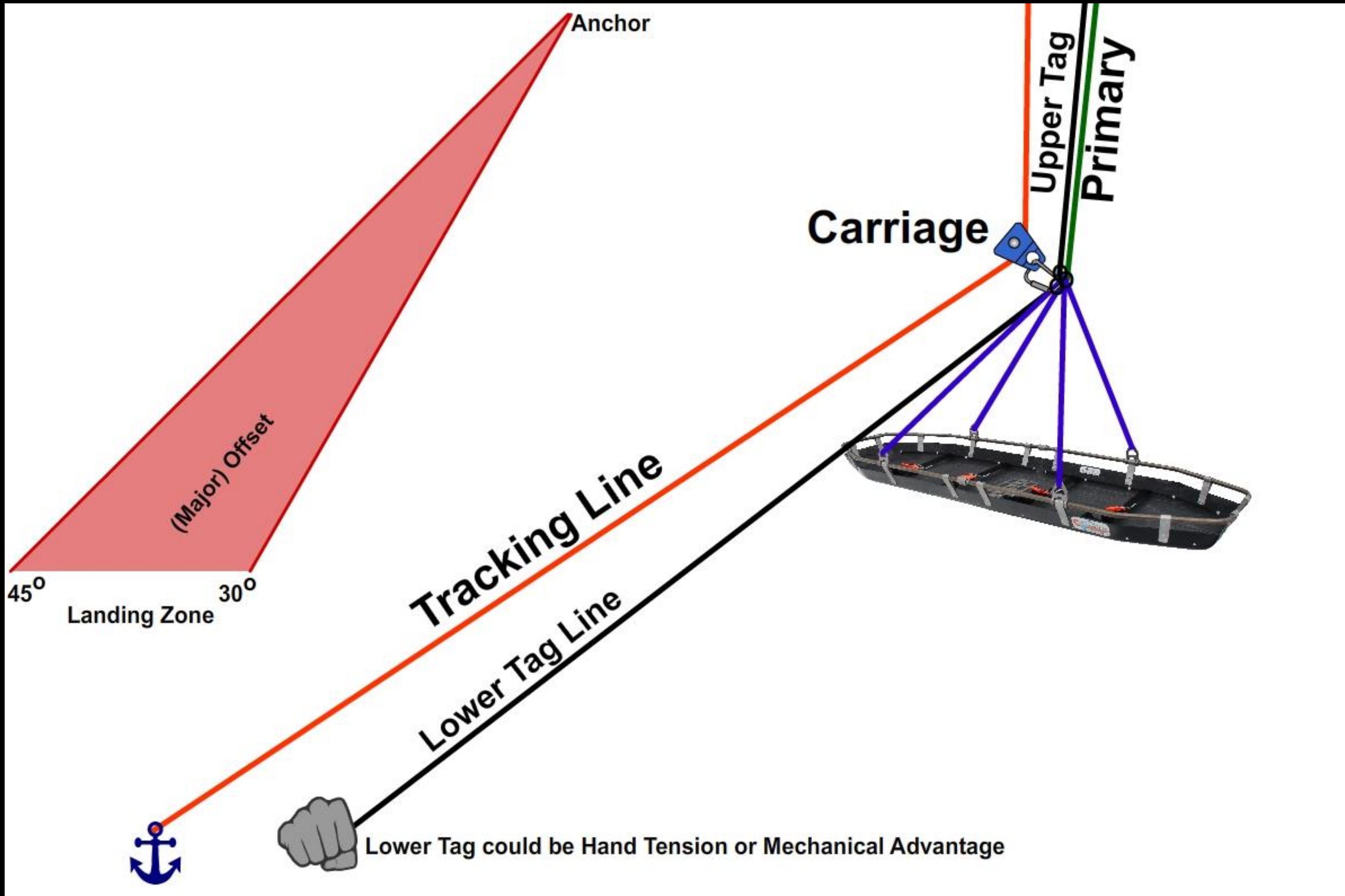
Guiding Line - (Minor)



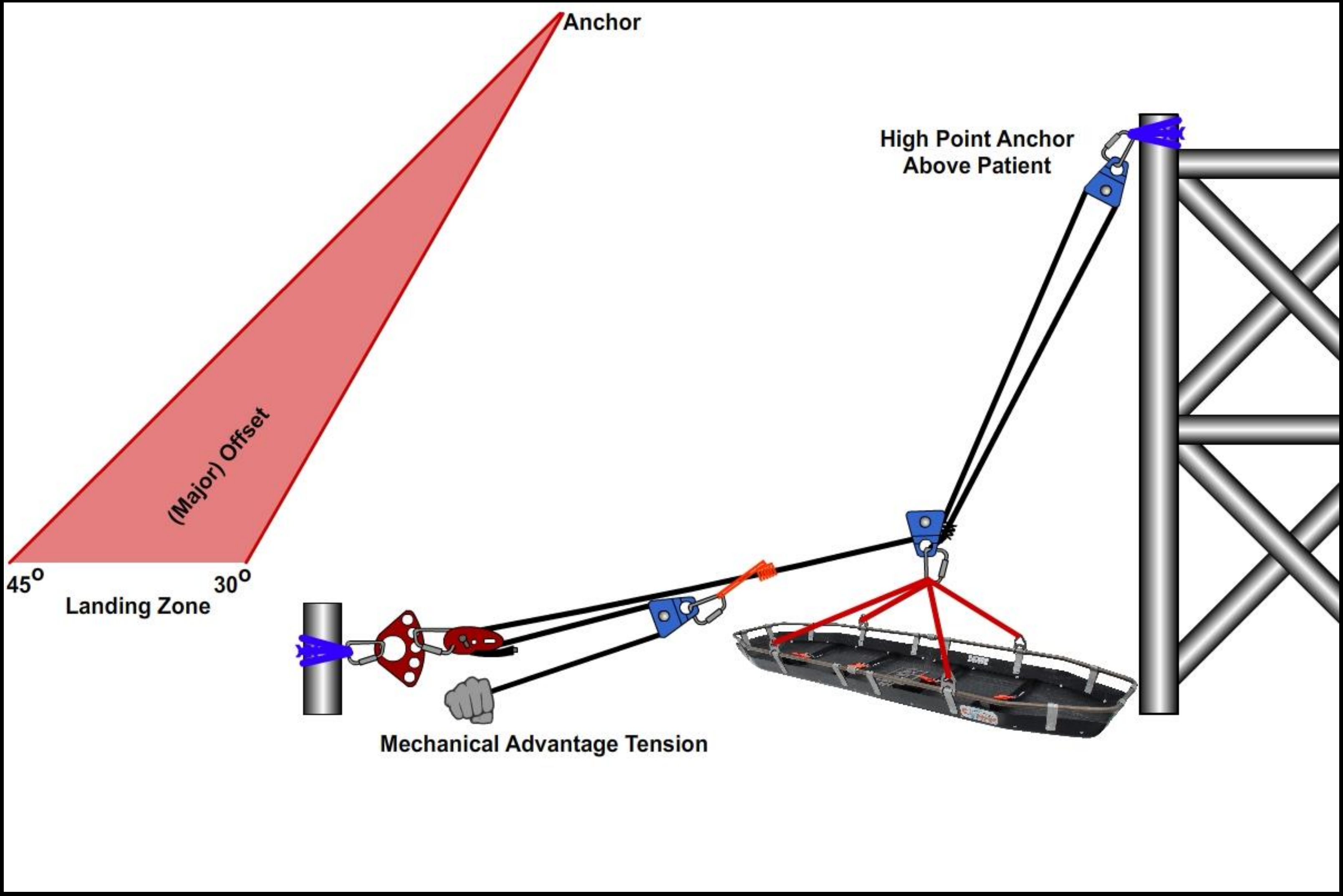
(Major) Offsets

(Major) Offset: A more sophisticated mechanical advantage rope system that allows for the articulation of the hanging package or individual. They include the Tracking Line, the Skate Block, the Deflection Line and the Two Rope Offset.

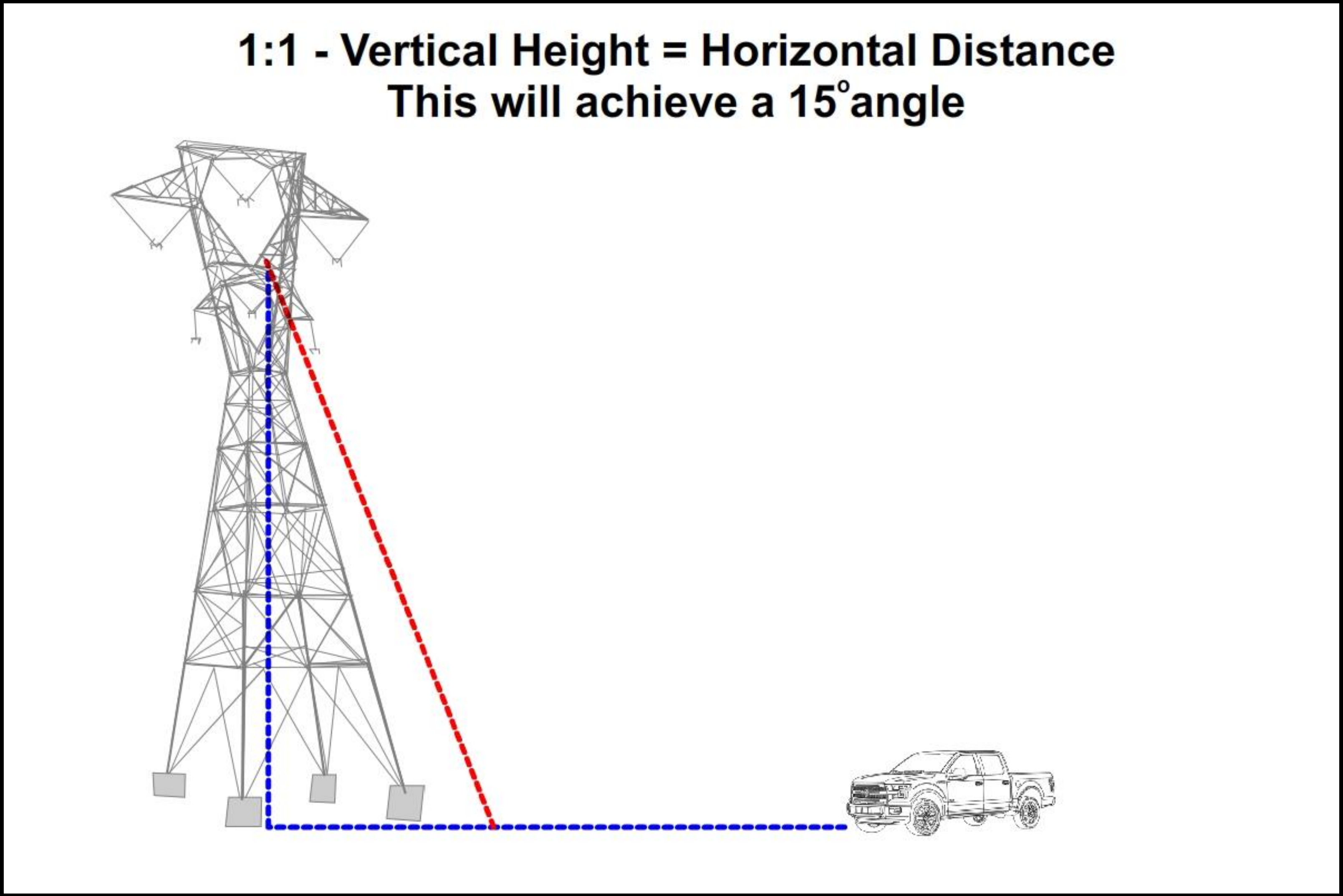
Tracking Line - (Major)



Skate Block - (Major)



Skate Block Distance



Deflection Line - (Major)

Two Rope Offset – (Major)

Dynamic Directional – (Major)

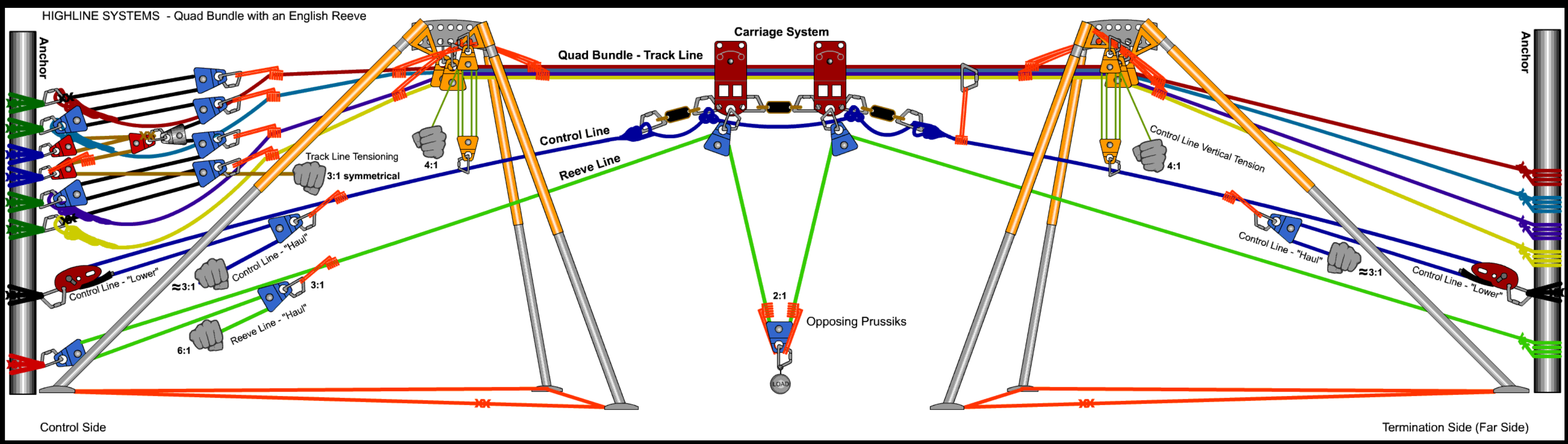
Drooping Highline – (Major)

Highlines

Highlines

Highline: A tensioned horizontal or diagonal rope system drawn tightly across a chasm to assist the access of rescuers, patients and/or equipment. A Highline consists of 4 overly-simplified basic parts: Trackline, Control Line, Carriage System and Reeve Line.

Highlines



Quad Bundle
Double Carriage
Single Control Line
English Reeve

Highlines

Highlines are one of the most dangerous and complex vertical rescue operations. Highlines incite the use of evolved rigging skills, performed by the most advanced rescue technicians. Under no circumstances should highline construction be attempted solely on the information within this material. Anyone interested in executing highlines must have intermediate skills as a prerequisite, and seek advanced training through an accredited school of rope rescue. This section only gives a general overview of the extremely complex subject of highlines.

99% of the time, most high angle rescues can be accomplished through the use of other methods combined with various forms of offsets. It is that rare 1% of the time that a highline might be needed. Typically, highlines are incorporated where a long span of difficult terrain or swift water must be negotiated for the successful extrication of a victim.

Highlines

Highlines should almost always be used as a last resort option. The benefit of a highline system is that it's a viable option that gets the job done; the caveat is that there are just about as many reasons why not to do one. As Pat Rhodes said "If over tensioning a rope and rope abrasion are the nemeses of rope rescue, than consider these two evil the devil incarnate to a highline."

By their very nature, a highline go against most every conventional rule of "safe" anchor building. In most cases, we try to keep the critical angle between multi-point anchors about 90° or less. At 120° the force at each anchor equals the weight of the load. With highlines, you are looking at a vector angle of at least 150° or more. This alone will multiply (with the rescue load in the middle of the trackline) the weight of the load anywhere from 2 times at 150° up to 11 times at 175 ° at each anchor, which is a tremendous amount of stress!

Highlines

Because of this tremendous stress highlines put on the anchors, here are some key principles that must be included in the construction of highlines:

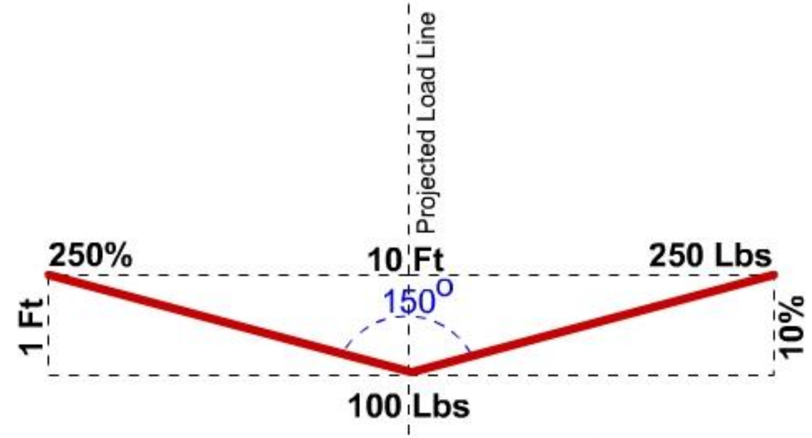
- Anchors must be bombproof.
- Full strength of the trackline must be utilized by eliminating all knots, and all excessive or sharp bends.
- All knots on the control lines must be bypassed.
- Maintaining a pulley tension system to the highlines utilizing a “slipping clutch” (or a poor mans load cell) in the form of system Prusiks. (8mm, 3-wrap)
- Incorporate a carriage system supporting the load.

As with any rope rescue operation, highlines even more so, must be able to pass the “whistle test” and the “critical point test”.

Track Lines

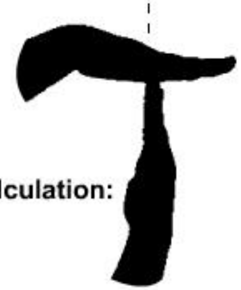
A tensioned horizontal or diagonal rope or set of ropes drawn tightly across a gap to allow the carriage system to travel. It is the "highway" in which the carriage system travels.

Deflection



10 Ft Span
100 lb Load
10% Deflection of span
250 lb Hit on the Anchors

Field Calculation:



TIME OUT - Terrible Angle (T)

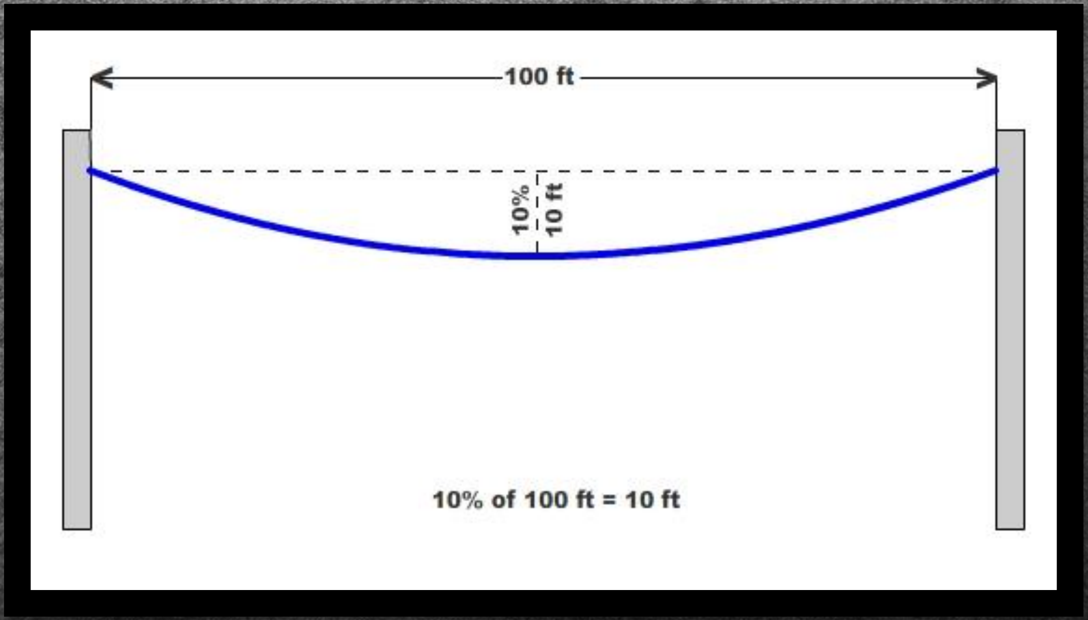
150°

Note: The following rigging calculation must be applied. Try to achieve 10% Deflection based on span. (10% of Span)

$$\frac{\text{Span x Load}}{(4)\text{ x Deflection}} = \text{Anchor Lbs} \qquad \frac{10\text{ft x }100\text{lbs}}{(4)\text{ x }1\text{ft}} \qquad \frac{1{,}000}{4} = 250\text{ lbs}$$

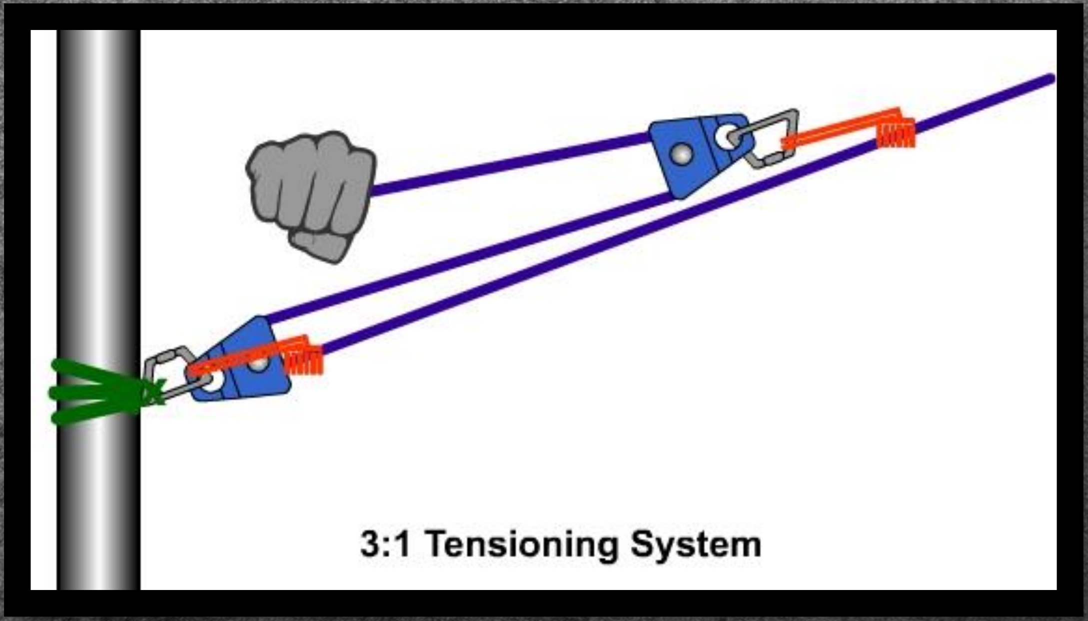
Single Track Line

A single track line is typically used when a larger amount of deflection between anchors may be allowed. As a fast rule, we want no less than 10% deflection on a single track line. Deflection is the amount of "sag" between the two anchor points. A simple example would be a 100-foot span between the anchors requiring no less than a 10% deflection. This would require a 10-foot sag on the track line because 10-foot is 10% of the100-foot distance.



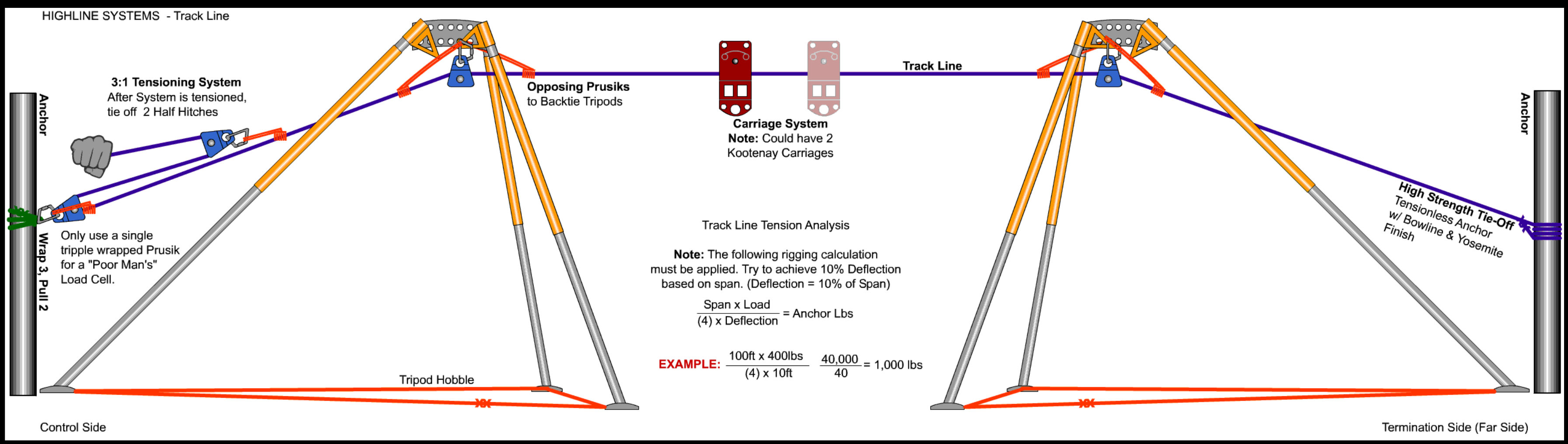
Single Track Line Tensioning

A Single Track line requires only a 3:1 tensioning system on the host rope to ensure that the proper amount of deflection is achieved.



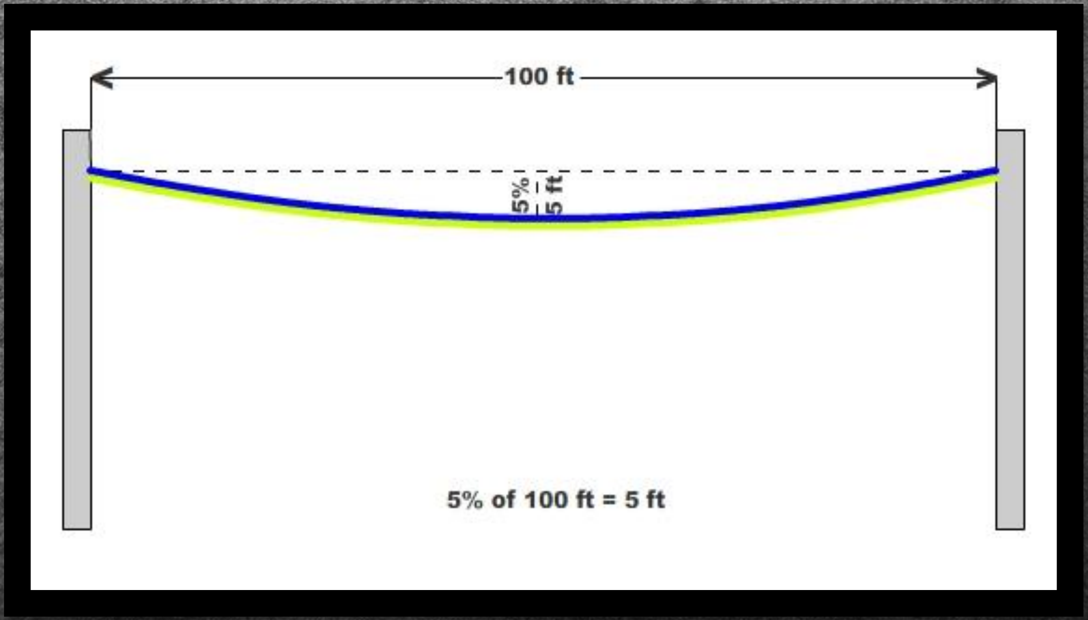
Host Rope – 3:1 Tensioning System

Single Track Line Setup



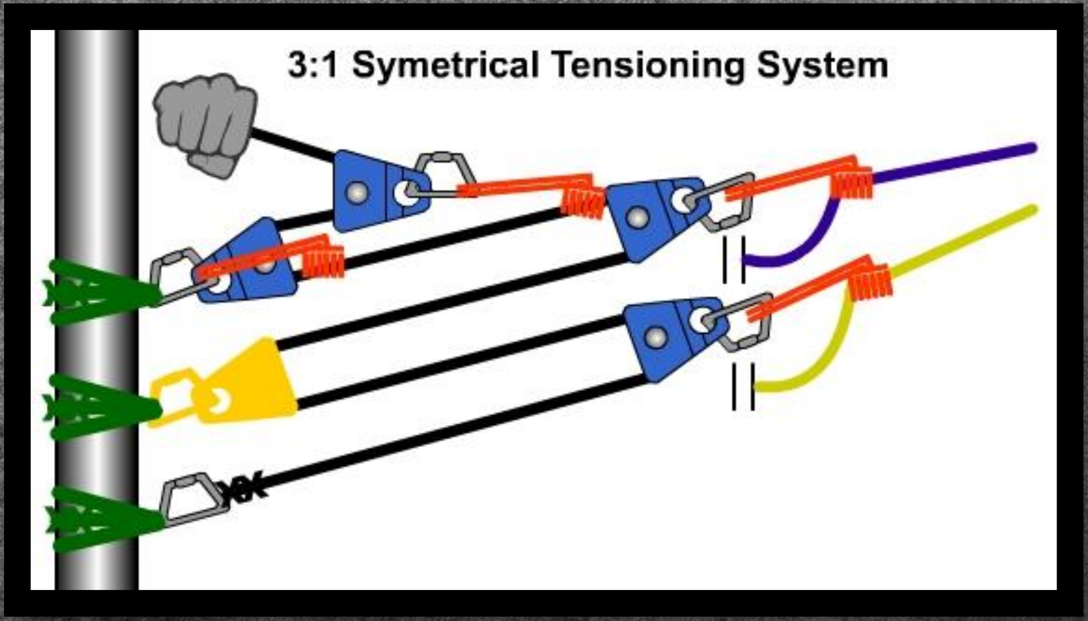
Twin Bundle Track Line

A Twin Bundle track line is typically used when a lesser amount of deflection between anchors may be needed. As a fast rule, we want no less than 5% deflection on a Twin Bundle track line. An example would be a 100-foot span between the anchors needing a 5% deflection. This would require a 5-foot sag on the track line because 5-foot is 5% of the100-foot distance. There is half the deflection, but two ropes. These two ropes will share the stress of the load.



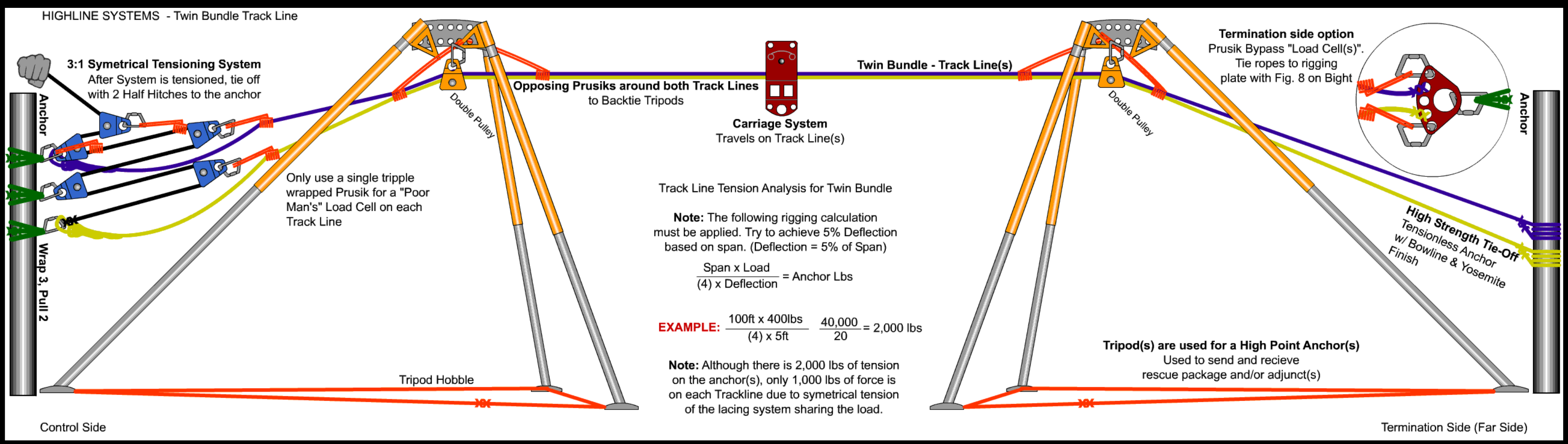
Twin Bundle Tensioning

A Twin Bundle track line requires a symmetrical tensioning system to ensure that both ropes share the load equally. This is managed by the use of a differential pulley. This tensioning system shows how to maintain symmetrical tension on both ropes.



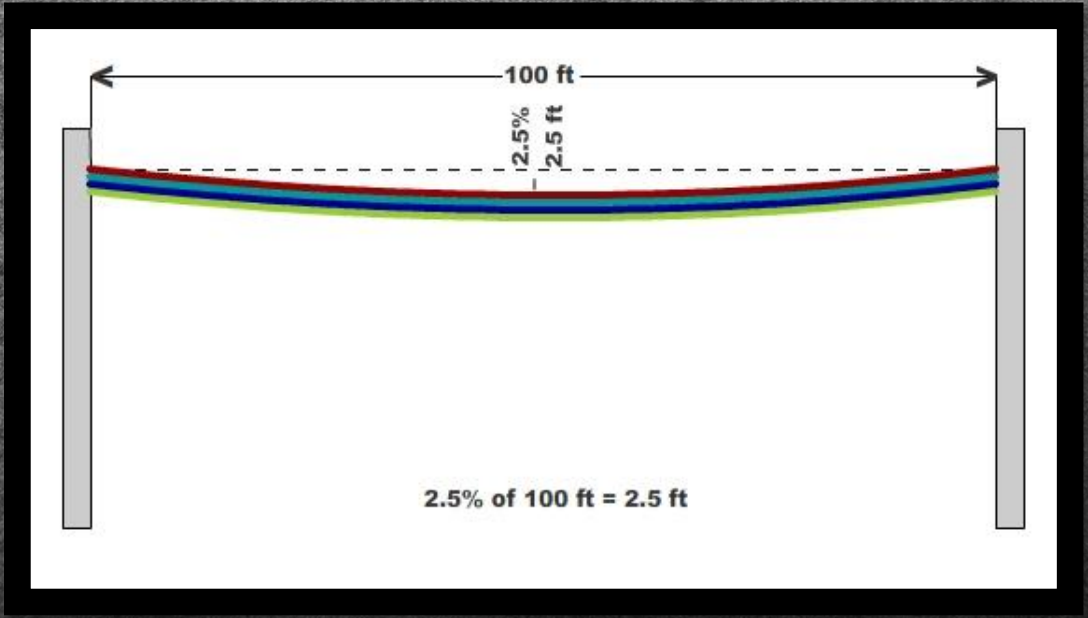
The **yellow** pulley is the differential pulley
Black Rope – Lacing and Tensioning System

Twin Bundle Setup



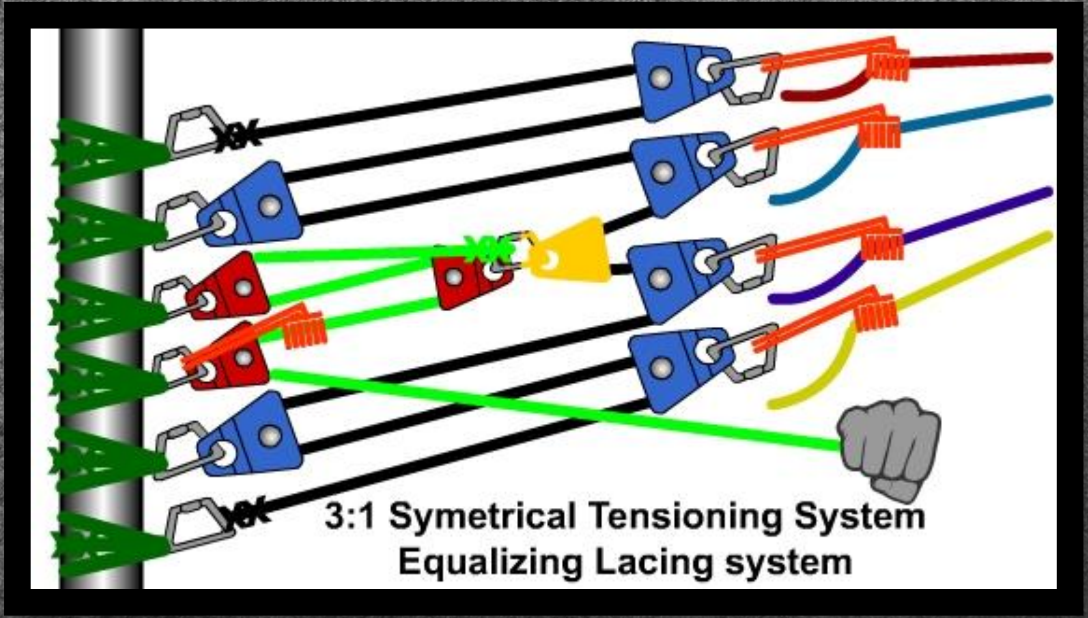
Quad Bundle Track Line

A Quad Bundle track line is typically used when the least amount of deflection between anchors is required. As a fast rule, we want no less than 2.5% deflection on a Quad Bundle track line. An example would be a 100-foot span between the anchors needing a 2.5% deflection. This would require 2.5-foot sag on the track line because 2.5-foot is 2.5% of the 100-foot distance. There is now 2.5% deflection, but four ropes. These four ropes will share the stress of the load.



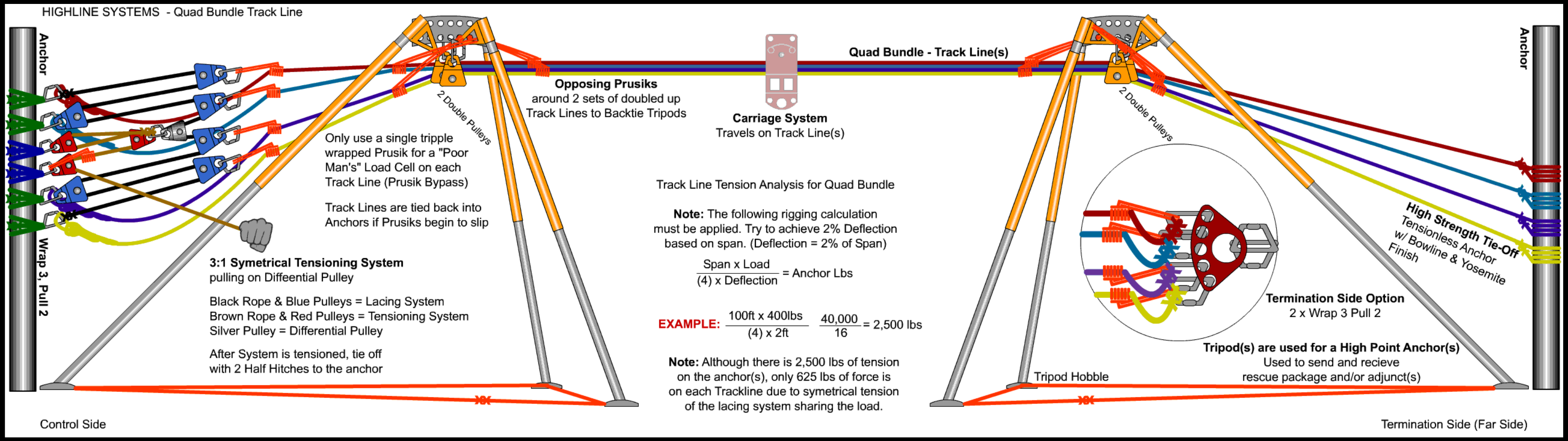
Quad Bundle Tensioning

A Quad Bundle track line requires a symmetrical tensioning system and a lacing system to ensure that all four ropes share the load equally. This is achieved by the use of a differential pulley on the lacing system that is being tensioned by the tensioning system. This tensioning system shows how to achieve symmetrical tension on all four ropes.



The **yellow** pulley is the differential pulley
Black Rope – Lacing System
Neon Green Rope – Tensioning System

Quad Bundle Setup

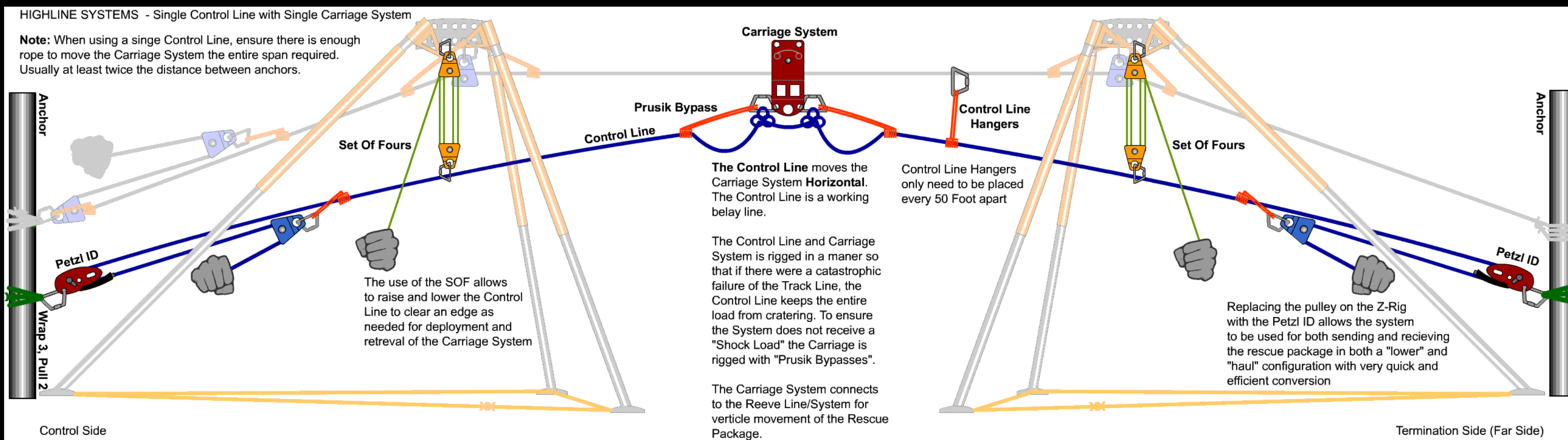


Control Lines & Carriage Systems

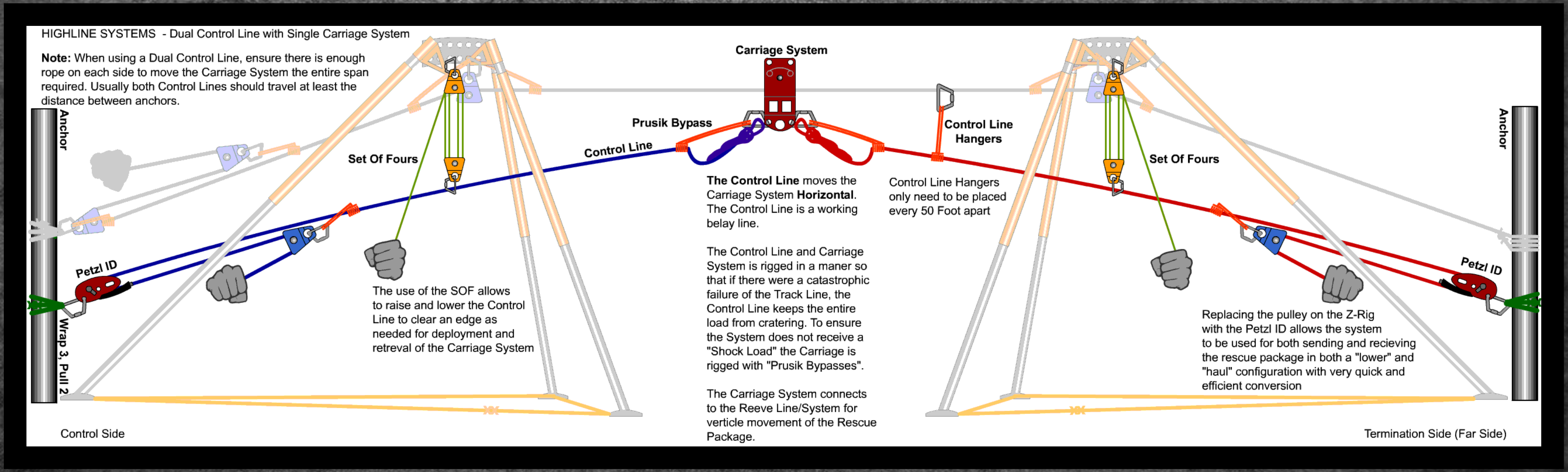
Control Lines: Ropes rigged on both ends of a highline used to control the movement of the carriage system horizontally.

Carriage: A carriage is the traveling support system for the load typically rigged with pulleys.

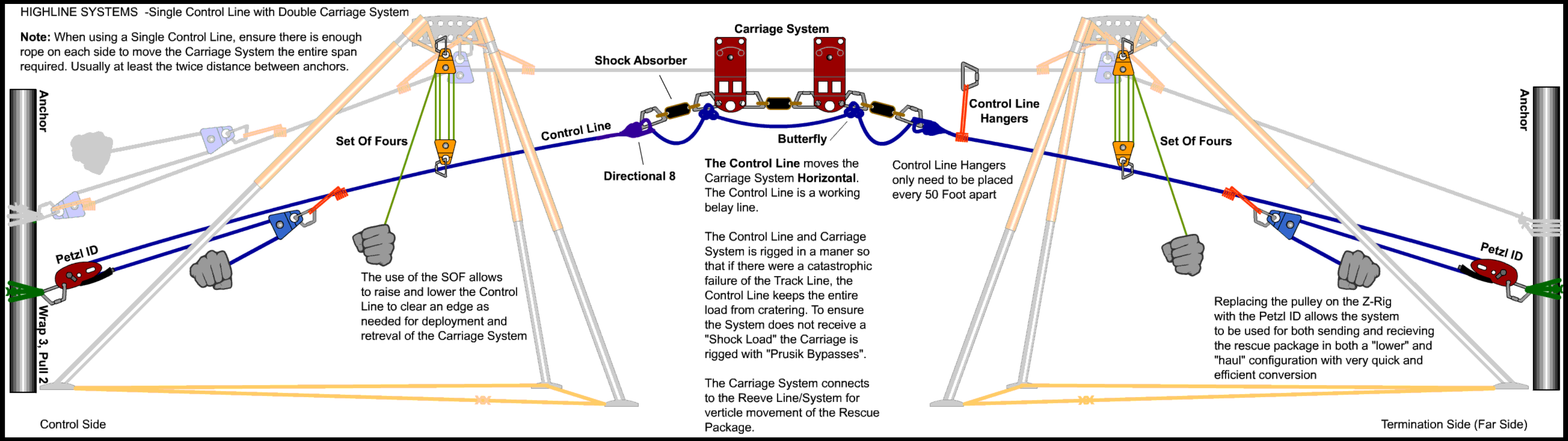
Single Control Line Single Carriage System



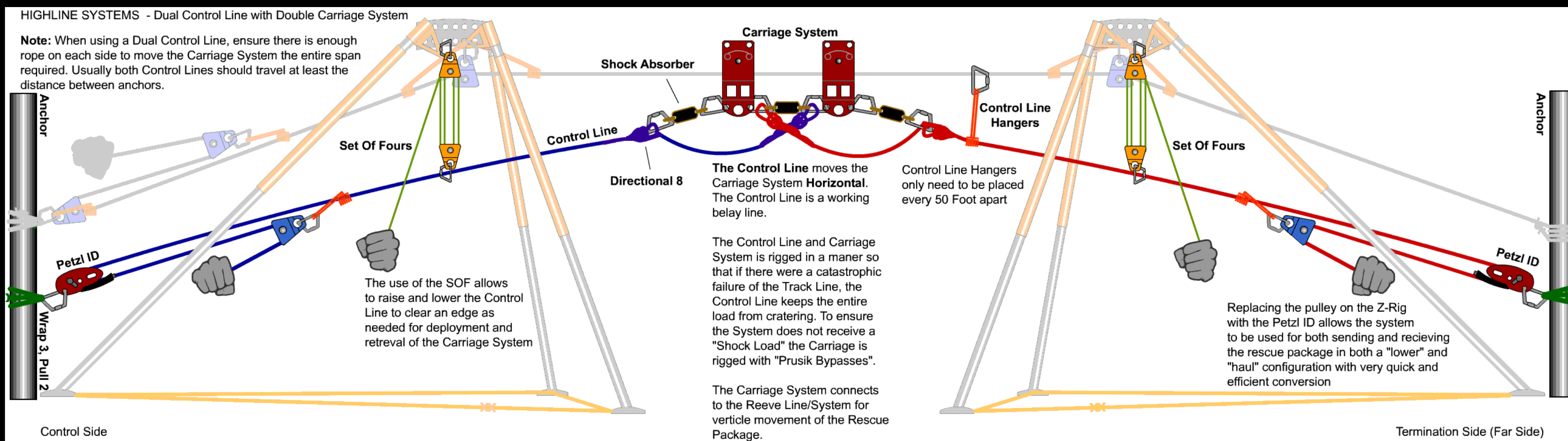
Dual Control Line Single Carriage System



Single Control Line Double Carriage System



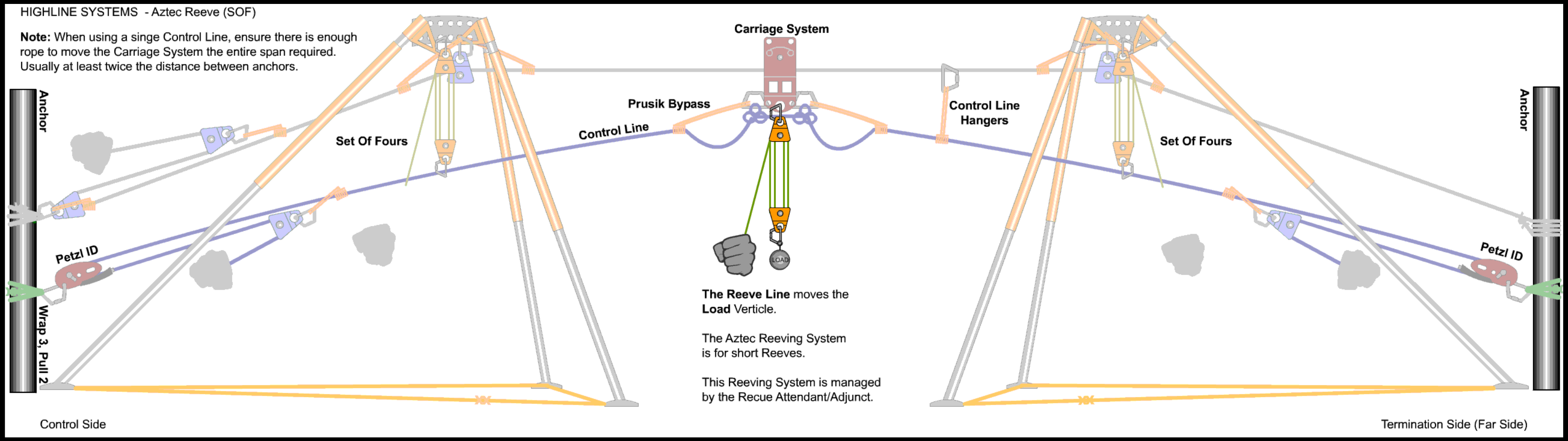
Dual Control Line Double Carriage System



Reeve Lines

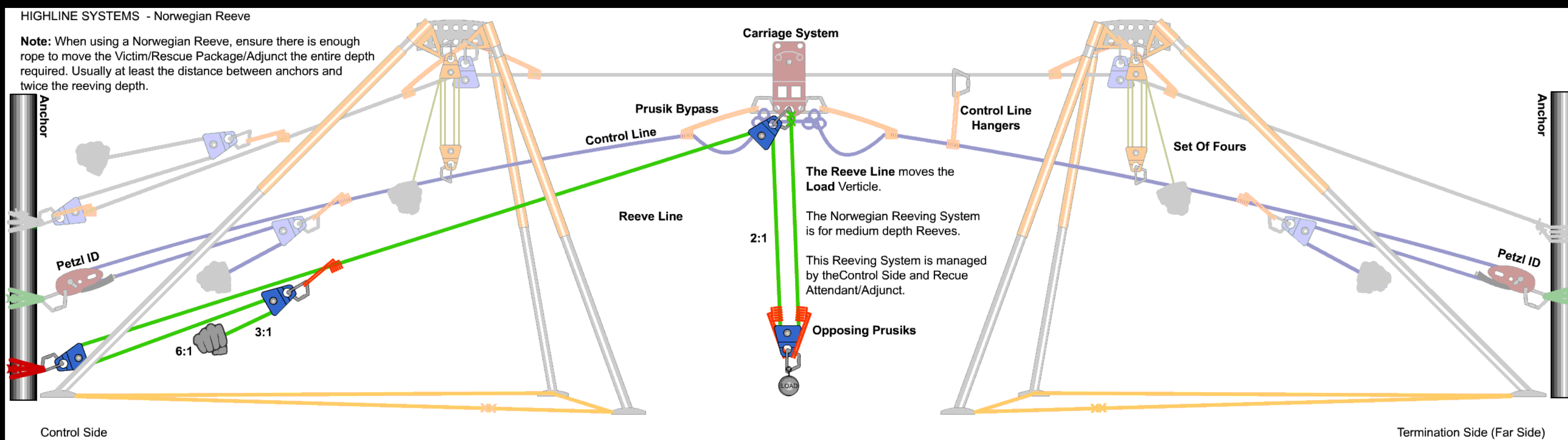
Reeve Line: A system that is rigged to move the victim and/or rescue adjunct vertical and/or up/down stream as needed.

AZTEK Reeve



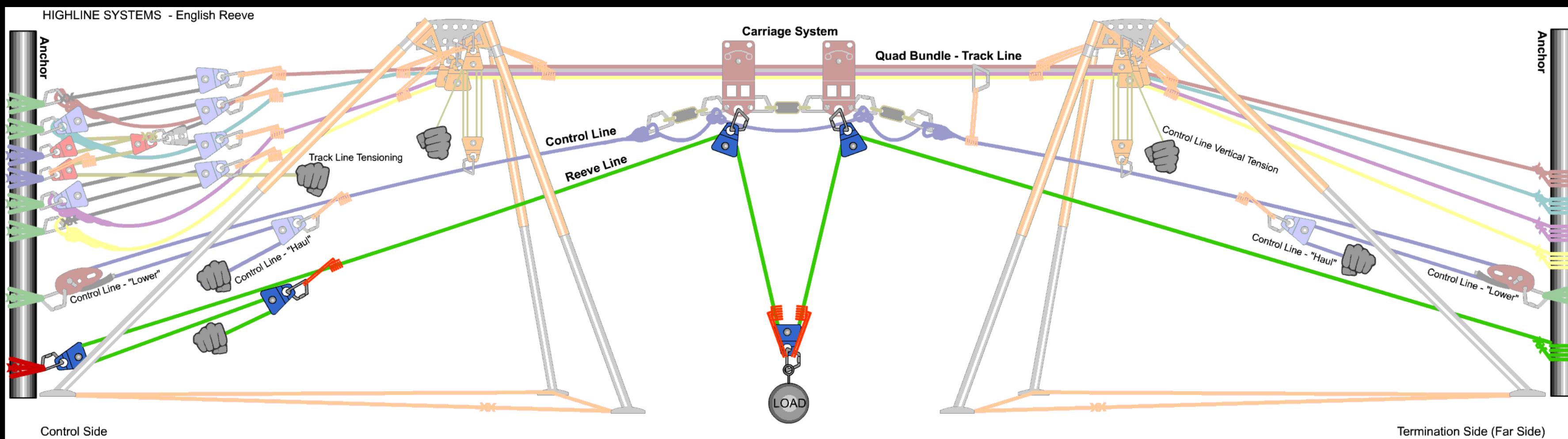
The AZTEK Reeve is more for horizontal transport of a patient than vertical. This reeve system is typically used to clear the top of an object or to clear or negotiate an edge due to sagging of the Track Line. This Reeving system is typically used for shallow reeving not more than 10-feet in depth.

Norwegian Reeve



The Norwegian Reeve is ideal for short to medium depth Reeves. This reeve system is typically used to descend into spaces that are between 10 and 30 feet in depth. The Norwegian Reeve is typically chosen over the English Reeve when rope consumption is an issue due to the span of the Highline. A downfall to the Norwegian Reeve is that as the control line moves horizontally, the reeve line must be managed at the same time to alleviate the altitude adjustment of the rescue package.

English Reeve



The English Reeve is the "Cadillac" of Reeve Systems. This reeve system is typically used to descend into spaces that are between 30 and several Hundred feet in depth. The English Reeve is used when rope consumption is not an issue due to the span of the Highline or depth. The English Reeve works completely independent from the Control line unlike the Norwegian Reeve as the system rolls through the carriage system without altitude changes while moving horizontally.

Incident Command

Incident Command

National Incident Management System – Overview

The National Incident Management System (NIMS) grew out of a notable lack of a unified command structure during 911 as well as Federal concern with the absence of an incident command system that was standard across the nation.

While originally ICS was the focus, NIMS soon grew into an entire emergency management organization system. It is the goal of NIMS to provide a consistent nationwide approach for responding to all kinds of incidents – no matter what the size, scope, cause or complexity.

Chief benefits of NIMS

- It is Applicable across jurisdictions and functions.
- Used for all types of emergencies
- Encourages interoperability
- Enhances the ability of different classes of responders to work effective together

Incident Command

Concepts and Principals

- NIMS provides a flexible framework that facilitates government and private entities working together to manage domestic incidents.
- NIMS provides a set of standardized organizational structures, as well as requirements for processes, procedures, and systems.

NIMS is comprised of several components that work together as a system to provide a national framework for preparing for, preventing, responding to, and recovering from domestic incidents

- Command and Management
- Preparedness
- Resource Management
- Communication and Information Management
- Supporting Technologies
- Ongoing Management and Maintenance

Incident Command

The Incident Commander

- Fix the responsibility for Command on a certain individual through a standard identification system, depending on the arrival sequence of employees, rescuers, and supervisors.
- Ensure that a strong, direct, and visible Command will be established from the onset of the incident.
- Establish an effective incident organization defining the activities and responsibilities assigned to the incident commander and the other individuals operating within the Incident Command System.
- Provide a system to process information to support incident management, planning, and decision making.
- Provide a system for the orderly transfer of Command to subsequent arriving supervisors

Incident Command

Command Tactical Objectives

The incident commander is responsible for the completion of the following tactical objectives:

- Provide for the continued safety of non-involved personnel and bystanders.
- Provide for the safety, accountability, and welfare of rescue personnel. This priority is on-going throughout the incident.
- Remove endangered occupants and treat the injured.
- Stabilize the incident.
- Conserve property.

Incident Command

The Incident Command System is used to facilitate the completion of the tactical objectives. The incident commander is the person who drives the Command system towards that end. The incident commander is responsible for building a Command structure that matches the organizational needs of the incident to achieve the completion of the tactical objectives for the incident. The functions of Command define standard activities that are performed by the incident commander to achieve the tactical objectives.

Incident Command

Functions of Command

The functions of Command include:

- Assume and announce Command and establish an effective operating position (Command Post).
- Rapidly evaluate the situation (size-up).
- Initiate, maintain, and control the communications process.
- Identify the overall strategy, develop an incident management plan, and assign companies and personnel consistent with plans and standard operating procedures.
- Develop an effective Incident Command organization.
- Review, evaluate, and revise (as needed) the Incident Management plan.
- Provide for the continuity, transfer, and termination of Command.

Incident Command

The incident commander is responsible for all of these functions. As Command is transferred, so is the responsibility for these functions. The first five (5) functions must be addressed immediately from the initial assumption of Command.

Establishing Command

The first rescuer to arrive at the scene of a major event requiring the rescue, victim treatment, and scene stabilization shall assume Command of the incident. The initial incident commander shall remain in Command until Command is transferred to a supervisor, higher qualified member/rescuer, or the incident is stabilized and Command is terminated.

When possible the first arriving rescuer initiates the Command process by giving an initial radio report.

Incident Command

The Radio Report should include:

- Identification of who is on the scene and talking.
- A brief description of the incident situation, (i.e. building size, occupancy, type of hazard, type of accident, etc.)
- Obvious conditions (flooding, hazmat spill, multiple patients, etc.).
- Brief description of action taken.
- Any obvious safety concerns.
- Assumption and identification of Command.
- Assume & Announce accountability location.

Incident Command

Incident Management

Size-up

Size-up is a rapid overview of the obvious, what is observed by everyone, and what is said by witnesses.

C.A.N. report (Conditions, Actions, and Needs)

This is an ongoing communication tool between rescue personnel and Command, the focus is on simple, direct communication.

Level 1 Staging

Level 1 staging is the immediate gathering location of first arriving rescue personnel, typically in close proximity to command, (typically, close enough for voice communication)

Incident Command

Level 2 Staging

Level 2 staging is a location designated by command where continued arriving resources gather and await further assignment. Level 2 staging is typically positioned well outside the field of action, yet close enough to advance forward to the scene within a couple of minutes. This allows for a systematic pooling of equipment, rescue and support personnel without overwhelming the scene with congestion.

Sectors or Groups

Sectors are subdivisions of larger command events that require a manageable span of control by Command.

Sectors are named by Command, typically using their location and/or function. i.e. North Sector, West Sector, Sector 2 (2nd floor), Rescue Sector, Hazmat Sector, or Treatment Sector, etc.

Incident Command

Each sector will have a Sector Officer who is responsible for communicating with Command (C.A.N. report) and supervising the actions within that sector.

Sections and Branches

Sections and Branches are subdivisions designed for extremely large command events that require a manageable span of control by Command.

Typical Order of Command Divisions

IC ---> Sections ---> Branches ---> Divisions/Groups/Sectors

Scene Management

Scene Management

1. What is the primary problem/concern
2. Risk assessment
3. Risk/Reward (rescue vs recovery)
4. Course of action (incident action plan)
5. Personnel feedback
6. Reevaluation of plan

Safety is always our first concern

Safe Rescue Process

- Written Rescue Preplan
- Drill/Train according to plan
- Scene survey
  - Macro to Micro
- Call for needed assistance
- Atmospheric Testing prior to entry
  - Respiratory protection requirements
- Incident Command system should already be in place
- Safety
  - Self
  - Team
  - Patient

Locate, **A**ccess, **S**tabilize, **T**ransport

Considerations

Condition of the patient

- Medical
- Trauma
- Cardiac Arrest
- Shock
- Psychological

Scene Surroundings

- Toxic Atmospheres
- Flammable Atmospheres
- Temperature Extremes
- Limited Room
- Engulfment Potential

Phase I - Size Up

- Initiate command
- Size-up/ Reconnaissance
  - Number and location of victims
- Gain control of the scene
- Rescue / Recovery determination
- Develop I.A.P. (Incident Action Plan-FEMA) or Written Rescue Plan
- Command Post
- Hazard control

Phase II - Pre-rescue

- Briefing
  - PPE
  - Communication
  - Rigging considerations
  - Hazards
- Rigging System
- Patient Packaging Considerations
- Accountability

Phase III - Rescue

- Rigging
- Rescuers In
- Patient Packaging
- Removal
- Rescuers Out
- Helicopter Considerations
- Accountability

Phase IV - Termination

- Rehab
- Debriefing
- Terminate Command
- Document
- Accountability
- Re-supply, Re-deploy
- CISD

Regulations

Standards and Regulations

Standards

Voluntary compliance

National Fire Protection Association (NFPA)

American National Standards Institute (ANSI)

Regulations

Enforced by law

Occupational Safety and Health Administration (OSHA)

Environmental Protection Agency (EPA)

Department of Transportation (DOT)

OSHA Regulations

29 CFR 1910.146: Confined Space & Confined Space Rescue

29 CFR 1910.147: Energy Isolation (LOTO)

29 CFR 1910.134: Respiratory Protection

29 CFR 1910.1200: Hazard Communication (HAZCOM)

29 CFR 1910.120: Hazardous Waste Operations & Emergency Response (HAZWOPER)

29 CFR 1926.57: Ventilation

NFPA Standards

NFPA 1983: Life safety rope and equipment for emergency services

This icon indicates NFPA 1983 Standard – 2017 link:

NFPA 1983

NFPA 1006: Rescue technician professional qualifications

This icon indicates NFPA 1006 Standard – 2017 link:

NFPA 1006

NFPA 1670: Operations and training for technical search and rescue incidents

This icon indicates NFPA 1670 Standard – 2017 link:

NFPA 1670

Linked content may require a high speed internet connection.

Confined Space

Confined Space Definition

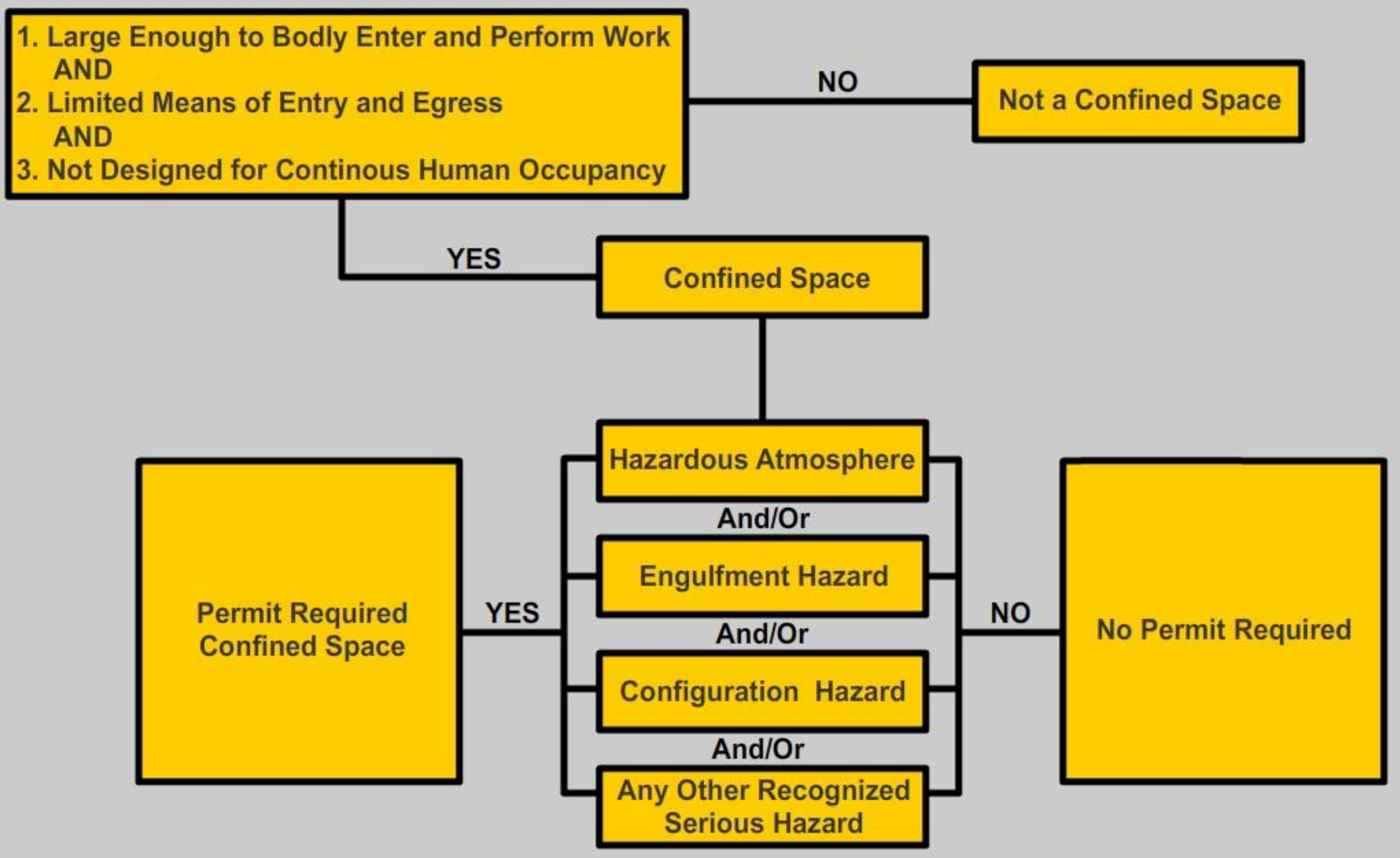
OSHA Definition:

- Large enough to bodily enter and preform work
- Not designed for continuous human occupancy
- Limited means of entry and egress

Note: All 3 criteria must be met to make it a confined space.

Permit Required Confined Space

How To Catagorize Work Space



OSHA Attendant Guidelines

Is the confined space entry attendant part of the rescue team?

The attendant may be a member of the rescue team, but may not perform entry rescue unless relieved by another qualified attendant. The attendant may perform non-entry rescue.

Can a company use an outside rescue service?

Yes, but it is up to the employer to assure that any outside service (i.e., municipal service or private service) members are properly trained and can respond in a timely manner.

OSHA Employer Guidelines

What does the standard require of employers?

The employer must develop and implement procedures for the following:

- Summoning rescue & emergency service.
- Rescuing entrants from confined spaces.
- Providing emergency services for rescued employees.
- Preventing unauthorized persons from performing rescue.

OSHA 911 Guidelines

Can an employer rely upon "911" for rescue?

No! Specifically disallowed.

OSHA wants to know:

- Who provides the off-site services?
- Where is the service based or located?
- Is the agreement by contract, letter, or verbal?
- How did employer determine adequacy of service?
- Are the rescue personnel adequately trained?
- How are they summoned?
- Is the service on-site or on-call during entry?
- What is their response time?
- How does employer verify availability during entry?

OSHA Equipment Guidelines

What equipment is required for rescue?

- OSHA provides no specific equipment requirements, but states that the employer ensures that the necessary equipment is available to perform a rescue from the space in question. This equipment must be listed on the entry permit.

What training requirements are applicable?

- Rescuers must have a clear understanding of their job responsibilities and it's risks.
- Rescuers must obtain sufficient formal education to perform a possible technical rescue.
- Rescuers must be able to repeat learned rescue skills during a critical incident.

OSHA Training Guidelines

What other training requirements are specific to rescue?

- Each rescuer must be provided with and trained in the use of necessary PPE and rescue equipment.
- Each rescuer must be trained to perform assigned rescue duties & have authorized entrant training.
- Annual hands-on rescue simulations from the actual spaces (or representative spaces) that may be encountered.
- A simulation from each type of space to be encountered
- All rescuers must have First Aid & CPR training, with at least one member being currently certified.

Excavation

Workers in Excavations

Access and means of egress. Stairs, ladders or ramps shall be provided where employees are required to enter trench excavations over 4-feet deep. The maximum distance of lateral travel (e.g., along the length of the trench) required to reach the means of egress shall not exceed 25-feet.

Structural ramps

- Structural ramps used solely by employees, as a means of access or a competent person shall design egress from excavations. Structural ramps used for access or egress of equipment shall be designed by a person qualified in structural design, and shall be constructed in accordance with the design.
- Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent movement or displacement.
- Structural members used for ramps and runways shall be of uniform thickness.
- Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.
- Structural ramps used in place of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

Workers in Excavations

Ladders

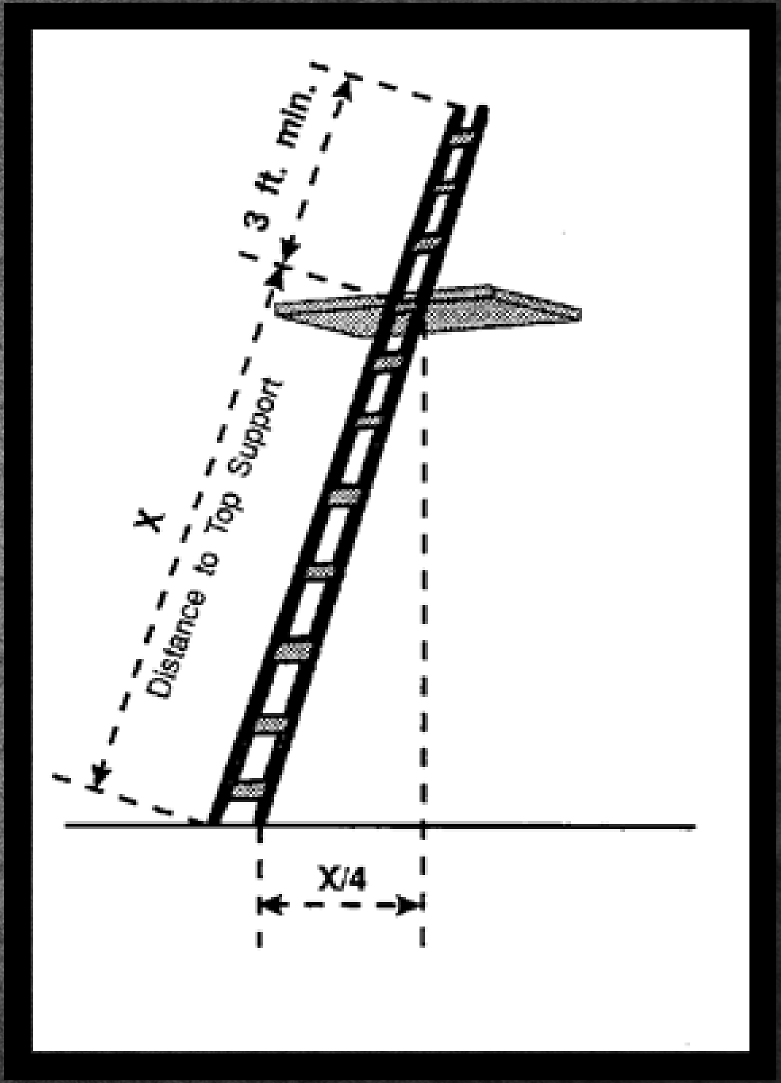
- When portable ladders are used, the ladder side rails shall extend a minimum of 3 feet above the upper surface of the excavation Ladders shall have nonconductive side rails if work will be performed near exposed energized equipment or systems.
- Two or more ladders, or a double-cleated ladder, will be provided where 25 or more employees will be conducting work in an excavation where ladders serve as the primary means of egress, or where ladders serve two-way traffic.
- Ladders will be inspected prior to use for signs of damage or defects. Damaged ladders will be removed from service and marked with “Do Not Use” until repaired.

Workers in Excavations

- Ladders shall be used only on stable and level surfaces unless secured. Ladders placed in any location where they can be displaced by workplace activities or traffic shall be secured, or barricades shall be used to keep these activities away from the ladder.

- Non-self-supporting ladders shall be positioned so that the foot of the ladder is one-quarter of the working length away from the support

- Employees shall not be allowed to carry any object or load while on the ladder that could cause them to lose their balance and fall.



Workers in Excavations

Exposure to vehicular traffic

- Employees exposed to vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material. Warning vests worn by flagmen shall be high-visibility red, yellow or orange, and shall be of reflectorized material if worn during night work.

Employee exposure to falling loads

- No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles provide adequate protection for the operator during loading and unloading operations.

Warning system for mobile equipment

- A warning system shall be used when mobile equipment is operated adjacent to the edge of an excavation if the operator does not have a clear and direct view of the edge of the excavation. The warning system shall consist of barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

Workers in Excavations

Hazardous atmospheres

- Test the atmosphere in excavations over 4-feet deep if a hazardous atmosphere exists or could reasonably be expected to exist. A hazardous atmosphere could be expected, for example, in excavations in landfill areas, in excavations in areas where hazardous substances are stored nearby, or in excavations near or containing gas pipelines.
- Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include proper respiratory protection or forced ventilation of the workspace.
- Forced ventilation or other effective means shall be used to prevent employee exposure to an atmosphere containing a flammable gas in excess of 10 percent of the lower flammability limit of the gas.
- When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, perform continuous air monitoring. The device used for atmospheric monitoring shall be equipped with an audible and visual alarm.

Workers in Excavations

- Atmospheric testing will be performed using a properly calibrated direct reading gas monitor. Direct reading gas detector tubes or other acceptable means may also be used to test potentially toxic atmospheres.
- Each atmospheric testing instrument shall be calibrated on a schedule and in the manner recommended by the manufacturer except:
- The Department prior to use shall recalibrate any atmospheric testing instrument that has not been used within thirty (30) days.
- The Department shall calibrate each atmospheric testing instrument at least every month and bump test every shift.
- Copies of calibration records will be forwarded to the Safety Coordinator.
- Each atmospheric testing instrument will be field checked immediately prior to use to ensure that it is operating properly.

Workers in Excavations

Personal protective equipment

- All employees working in trenches or excavations shall wear approved hardhats and steel toed shoes or boots.
- Employees exposed to flying fragments, dust, or other materials produced by drilling, sawing, sanding, grinding and similar operations shall wear approved safety glasses with side shields.
- Employees exposed to hazards produced by, or performing, welding, cutting, or brazing operations shall wear, as determined by the Project Manager, approved spectacles or a welding faceshield or helmet.
- Employees entering bell-bottom pier holes or other similar deep and confined footing excavations shall wear a harness with a lifeline securely attached to it. The lifeline shall be separate from any line used to handle materials and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.
- Employees shall wear, as determined by the Project Manager, approved gloves or other suitable hand protection.

Workers in Excavations

- Employees using, or working in the immediate vicinity of, hammer drills, masonry saws, jackhammers or similar high noise producing equipment shall wear suitable hearing protection.
- Each employee at the edge of an excavation 6 feet or more deep shall be protected from falling. Guardrail systems, fences, barricades, covers, or a tie-back system meeting the requirements of the Fall Protection Program shall provide fall protection.
- Emergency rescue equipment, such as breathing apparatus, a safety harness and line, and a basket stretcher shall be readily available where hazardous atmospheric conditions exist or may develop during work in an excavation. This equipment shall be attended when in use. Only personnel that have received approved training and have appropriate equipment shall attempt retrieval that would require entry into a hazardous atmosphere. If entry into a known hazardous atmosphere must be performed, then the Safety Coordinator shall be given advance notice so that the hazards can be evaluated and rescue personnel placed on standby if necessary.

Workers in Excavations

Walkways and guardrails

- Walkways shall be provided where employees or equipment are permitted to cross over excavations. Guardrails shall be provided where walkways, accessible only to on-site project personnel, are 6 feet or more above lower levels.

Protection from hazards associated with water accumulation

- Employees shall not work in excavations that contain or are accumulating water unless precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions taken could include, for example, special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of safety harnesses and lifelines.
- If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operation shall be monitored by a person trained in the use of the equipment.

Workers in Excavations

- If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation. Precautions shall also be taken to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains shall be re-inspected by the Project Manager to determine if additional precautions should be taken.
- The Project Manager shall inform workers of the precautions or procedures that are to be followed if water accumulates or is accumulating in an excavation.

Workers in Excavations

Stability of adjacent structures

The Project Manager will determine if the excavation work could affect the stability of adjoining buildings, walls, sidewalks or other structures.

- Support systems (such as shoring, bracing, or underpinning) shall be used to assure the stability of structures and the protection of employees where excavation operations could affect the stability of adjoining buildings, walls, or other structures.
- Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:
  1. A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
  2. The excavation is in stable rock; or
  3. A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or
  4. A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

Workers in Excavations

- Sidewalks, pavements and appurtenant structure shall not be undermined unless a support system or other method of protection is provided to protect employees from the possible collapse of such structures.
- Where review or approval of a support system by a registered professional engineer is required, the Department shall secure this review and approval in writing before the work is begun. A copy of this approval shall be provided to the Safety Coordinator.

Workers in Excavations

Protection of employees from falling objects and loose rocks or soil

- Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of:
  1. Scaling to remove loose material;
  2. Installation of protective barricades, such as wire mesh or timber, at appropriate intervals on the face of the slope to stop and contain falling material; or
  3. Benching sufficient to contain falling material.
- Excavation personnel shall not be permitted to work above one another where the danger of falling rock or earth exists.
- Employees shall be protected from excavated materials, equipment or other materials that could pose a hazard by falling or rolling into excavations.
- Protection shall be provided by keeping such materials or equipment at least 2 feet from the edge of excavations, by the use of restraining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

Workers in Excavations

- Materials and equipment may, as determined by the Project Manager, need to be stored further than 2 feet from the edge of the excavation if a hazardous loading condition is created on the face of the excavation.
- Materials piled, grouped or stacked near the edge of an excavation must be stable and self-supporting.

Inspection by the Project Manager

- The departmental Project Manager shall conduct daily inspections of excavations, adjacent areas, and protective systems for evidence of a situation that could result in possible cave-ins, failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the Project Manager prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard-increasing occurrence. These inspections are only required when the trench will be or is occupied by employees.
- Where evidence of a situation that could result in a possible cave-in, failure of protective systems, hazardous atmosphere, or other hazardous conditions, exposed employees shall be removed from the area until precautions have been taken to assure their safety.

Workers in Excavations

- The Project Manager shall maintain a written log of all inspections conducted. This log shall include the date, work site location, results of the inspection, and a summary of any action taken to correct existing hazards.

Excavation Protective Systems

Protection of employees in excavations

- Employees in an excavation shall be protected from cave-ins by using either an adequate sloping or benching system or an adequate support or protective system. The only exceptions are:
  1. Excavations made entirely in stable rock; or
  2. Excavations less than 5-feet in depth where examination of the ground by the Project Manager provides no indication of a potential cave-in.
- Protective systems shall be capable of resisting all loads that could reasonably be expected to be applied to the system.

Design of sloping and benching systems

- The slope and configuration of sloping and benching systems shall be selected and constructed by the Project Manager as follows:

Excavation Protective Systems

Option 1 - Allowable configurations and slopes

- Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the Project Manager uses one of the other options listed below.
- The slopes used shall be excavated in accordance with the slopes shown for Type C soil in Appendix B.

Option 2 - Determination of slopes and configurations using Appendix A & B

- Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall meet the requirements set forth in appendix A & B.

Option 3 - Designs using other tabulated data

- The design of sloping or benching systems may be selected from, and shall be constructed in accordance with, other tabulated data, such as tables and charts. The tabulated data used must be in written form and include all of the following:

Excavation Protective Systems

a. Identification of the factors that affect the selection of a sloping or benching system;
b. Identification of the limits of use of the data, including the maximum height and the angle of the slopes determined to be safe;
c. Other information needed by the user to make correct selection of a protective system.

- One copy of the tabulated data that identifies the registered professional engineer who approved the data shall be maintained at the job site during construction of the protective system. After that time the data may be stored off the job site, but a copy of the data shall be made available to the Safety Coordinator upon request.

Option 4 - Design by a registered professional engineer

Sloping and benching systems not utilizing Option (1), Option (2) or Option (3) shall be approved by a registered professional engineer.

Excavation Protective Systems

Option 4 - Design by a registered professional engineer

Sloping and benching systems not utilizing Option (1), Option (2) or Option (3) shall be approved by a registered professional engineer.

- Designs shall be in written form and shall include at least the following:
  a. The maximum height and angle of the slopes that were determined to be safe for the particular project;
  b. The identity of the registered professional engineer approving the design.
- At least one copy of the design shall be maintained at the job site while the slope is being constructed. After that time the design need not be at the job site, but a copy shall be made available to the Safety Coordinator upon request.

Excavation Appendix A

Soil Classification – Type B Soil

Excavation Appendix B

Soil Classification – Type C Soil

Atmospheric Monitoring

Monitoring Confined Spaces

- Collect a sample from top, middle, and bottom or every 4 feet if possible

- Minimum response time specified by the manufacturer (rule of thumb: 1 second per foot of hose)

- Do not allow the sampling tube to touch or rest on the bottom

- Check for O2, LEL, and Toxic vapors in that order

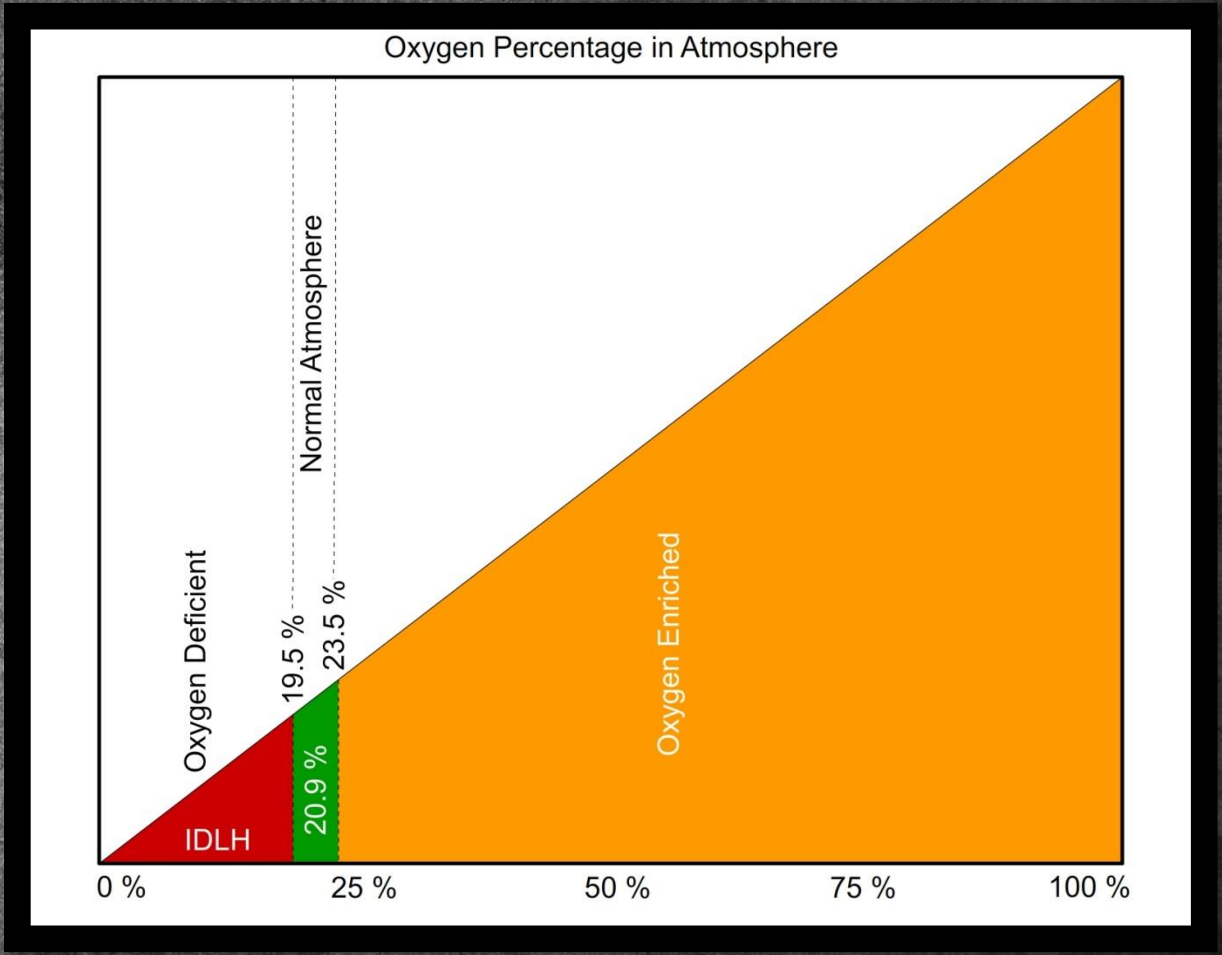
Oxygen In Atmosphere

During atmospheric testing, Oxygen concentrations should be between 19.5% and 23.5%.

Typical Oxygen concentration in atmosphere is 20.9%

Any reading below 19.5% is classified as Oxygen deficient and IDLH.

Any Reading above 23.5% is classified as Oxygen Enriched.

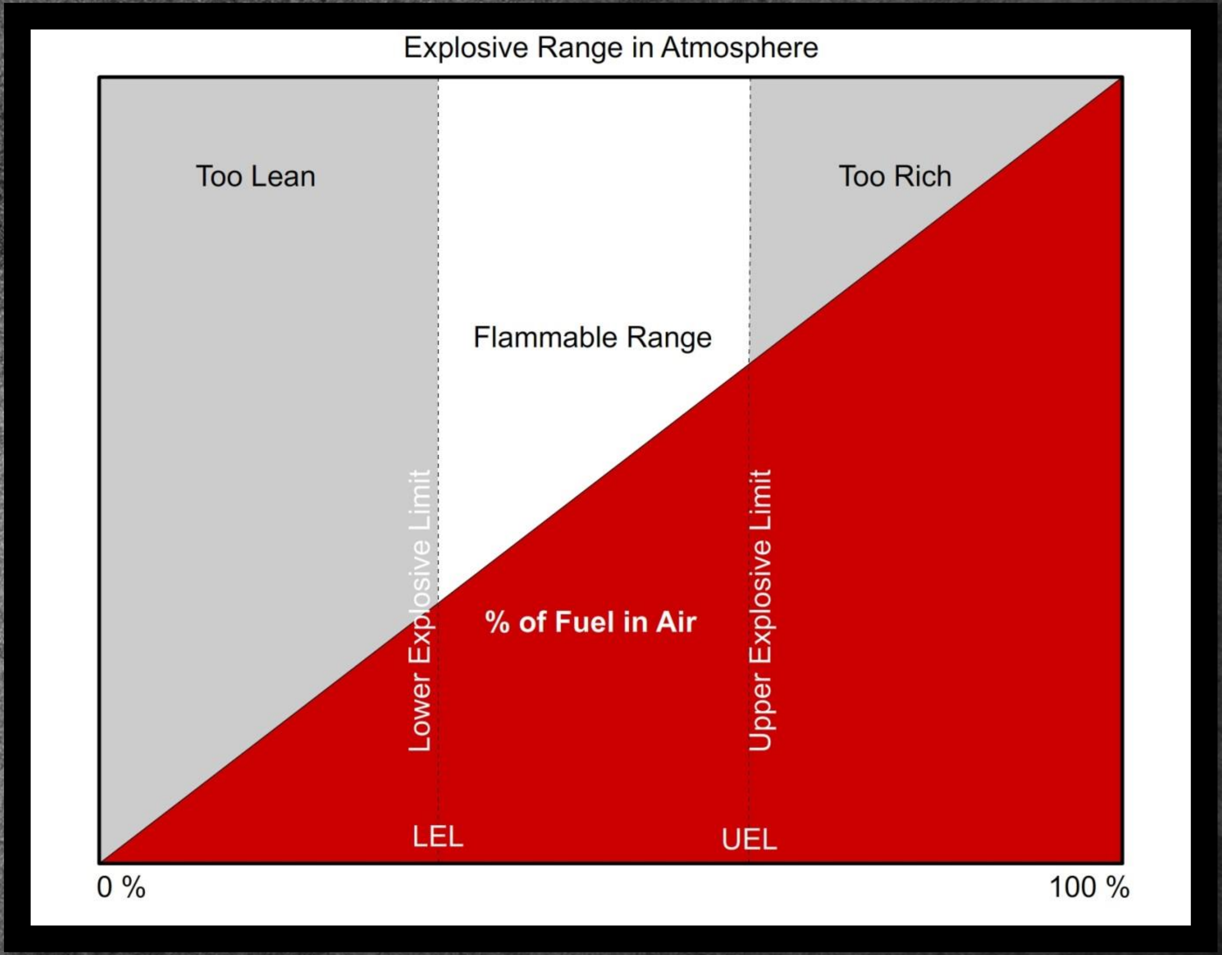


Flammability (LEL)

The Explosive Range is the measurement of fuel in atmosphere.

If the % of fuel is below the LEL then there is not enough Fuel to support combustion (Lean). If the % of fuel is above the UEL there is too much fuel to support combustion (Rich).

Between the LEL and the UEL is the Flammable Range, here there is the correct amount of fuel for the amount of oxygen to support combustion.

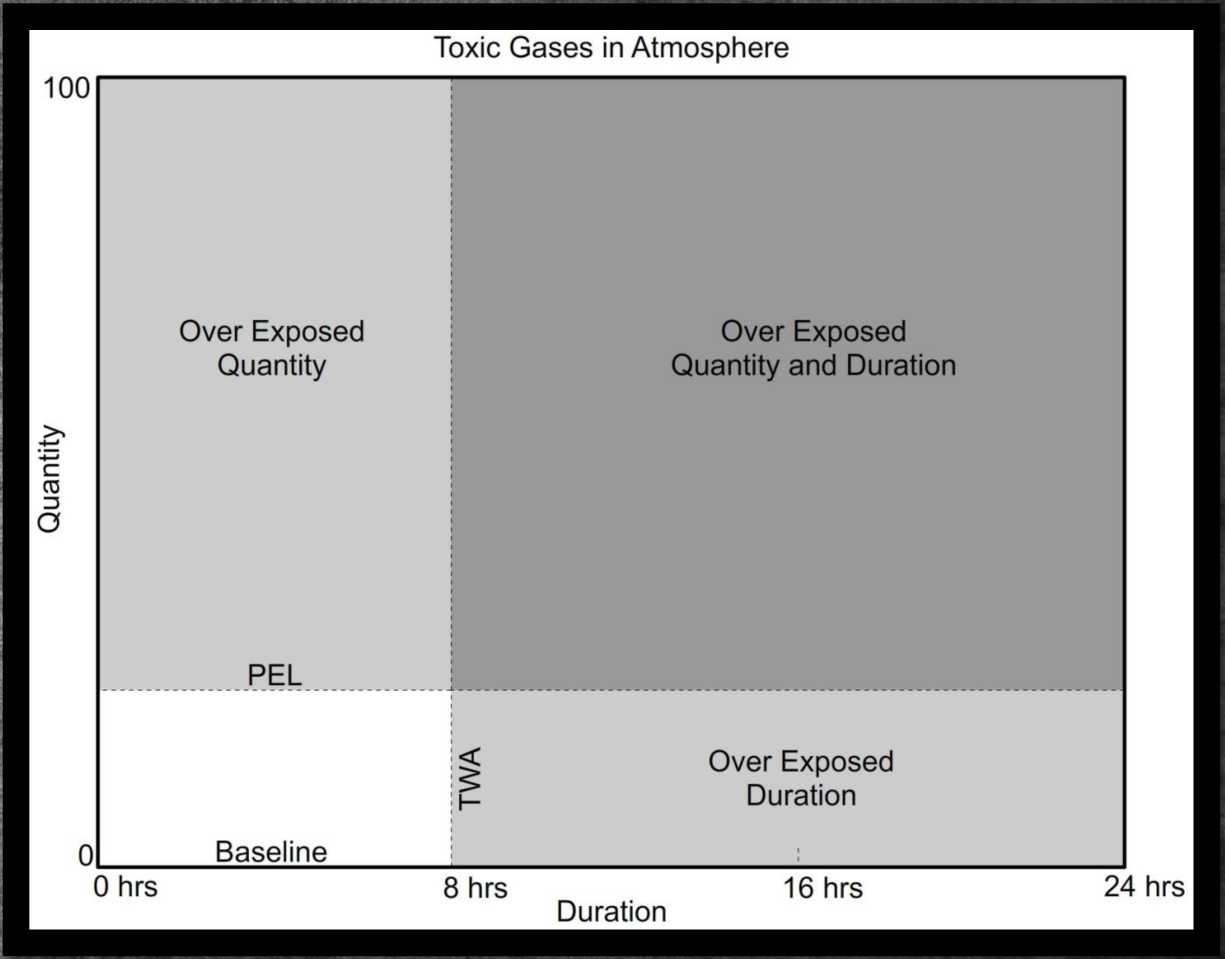


Toxic Gases

A PEL is a quantity usually given as a time-weighted average (TWA), which is the average exposure workers have to a substance without experiencing significant adverse health effects over the standardized work period (an eight-hour a day, 40-hour per week work schedule).

The TWA is the duration of time a person can be exposed.

Chemical exposures should remain below the PEL or TWA of that chemical unless additional protective equipment is worn.



Nine Basic Rules for Atmospheric Monitoring

1. Know monitor's limitations per manufacturer
2. Know monitor's operational parameters
3. Always fresh air calibrate monitor
4. Sample from a small opening if possible, stay upwind
5. Many gases migrate towards the opening of the space
6. Monitor in the proper order (O_2, LEL & other such as toxic gases)
7. Consider vapor density (heavier or lighter than air)
8. Be sure all batteries are charged after each use
9. Power on monitor in known atmosphere

Respiratory Protection

Respiratory Protection

This does not apply to contractors as they are responsible for providing their own respiratory protection programs and respiratory protective equipment. This is a risk management program designed for the selection of respiratory protection a rescue team should wear.

Supervisors shall contact the HSEQT Manager prior to non-routine work, which may expose workers to hazardous substances or oxygen deficient atmospheres. Examples of work, which may require the use of respirators includes, but are not limited to:

- Asbestos abatement activities
- Abrasive blasting
- Cutting or melting lead or stripping lead-based paints from surfaces
- Welding or burning
- Painting, especially with epoxy or organic solvent coatings
- Using solvents, thinners, or degreasers
- Any work which generates large amounts of dust
- Working in a confined space

Respiratory Protection Procedure

Procedure:

Selection – Respirators shall be NIOSH-approved and selected on the basis of the potential hazards to which the worker is exposed.

Medical Evaluations – The employee shall fill out a Medical Evaluation Questionnaire (MEQ) before being fit tested. In the event of prolonged respirator use, the wearer should have a medical examination to determine if he/she is medically able to wear respiratory protective equipment without aggravating a pre-existing medical condition.

Respirator Fit Testing – A fit test shall be used to determine the ability of each individual respirator wearer to obtain a satisfactory fit with any air-purifying respirator. Quantitative fit tests will be performed. Personnel must successfully pass the fit test before being issued an air-purifying respirator.

Respiratory Protection Procedure

Training – Appropriate training and instructions in the proper use of each type of respirator shall be provided. Respirator users and their supervisors will receive training on the contents of the Respiratory Protection Program and their responsibilities under it. They will be trained on the proper selection and use, as well as the limitations of the respirator. Training also covers how to ensure a proper fit before use and how to determine when a respirator is no longer providing the protection intended.

Types of Respirators:

1. Air-Purifying Respirator

These respirators remove air contaminants by filtering, absorbing, adsorbing, or chemical reaction with the contaminants as they pass through the respirator canister or cartridge. This respirator is to be used only where adequate oxygen (19.5 to 23.5 percent by volume) is available. Air-purifying respirators can be classified as follows:

Respiratory Protection Types

2. Particulate removing respirators, which filter out dusts, fibers, fumes and mists. These respirators may be single-use disposable respirators or respirators with replaceable filters.

NOTE: Surgical masks do not provide protection against air contaminants. They are never to be used in place of an air-purifying respirator. They are for medical use only.

3. Gas and vapor-removing respirators, which remove specific individual contaminants or a combination of contaminants by absorption, adsorption or by chemical reaction. Gas masks and chemical-cartridge respirators are examples of gas- and vapor-removing respirators.

4. Combination particulate/gas and vapor-removing respirators, which combine the respirator characteristics of both kinds of air-purifying respirators.

Respiratory Protection Types

5. Supplied-Air Respirators

These respirators provide breathing air independent of the environment. Air must be Grade D or better and cylinders containing air must meet DOT requirements. A Certificate of Analysis must accompany any cylinder that is being used for breathing air. Such respirators are to be used when the contaminant has insufficient odor, taste or irritating warning properties, or when the contaminant is of such high concentration or toxicity that an air-purifying respirator is inadequate. Supplied- air respirators, also called air-line respirators, are classified as follows:

a. Demand - This respirator supplies air to the user on demand (inhalation), which creates a negative pressure within the facepiece. Leakage into the facepiece may occur if there is a poor seal between the respirator and the user's face.

b. Pressure-Demand - This respirator maintains a continuous positive pressure within the facepiece, thus preventing leakage into the facepiece.

c. Continuous Flow - This respirator maintains a continuous flow of air through the facepiece and prevents leakage into the facepiece.

Respiratory Protection Types

6. Self-Contained Breathing Apparatus (SCBA)

This type of respirator allows the user complete independence from a fixed source of air and offers the greatest degree of protection but is also the most complex. Air must be Grade D or better and cylinders containing air must meet DOT requirements. A Certificate of Analysis must accompany any cylinder that is being used for breathing air. Training and practice in its use and maintenance is essential. This type of device will be used in emergency situations only.

Respirator Cartriges

Identification of Respirator Cartridges and Gas Mask Canisters

Respirator cartridges and canisters are designed to protect against individual or a combination of potentially hazardous atmospheric contaminants, and are specifically labeled and color coded to indicate the type and nature of protection they provide.

An approved label on the respirator will also specify the maximum concentration of contaminant(s) for which the cartridge or canister is approved. For example, a label may read:

"DO NOT WEAR IN ATMOSPHERES IMMEDIATELY DANGEROUS TO LIFE. MUST BE USED IN AREAS CONTAINING AT LEAST 20 PERCENT OXYGEN. DO NOT WEAR IN ATMOSPHERES CONTAINING MORE THAN ONE-TENTH PERCENT ORGANIC VAPORS BY VOLUME. REFER TO COMPLETE LABEL ON RESPIRATOR OR CARTRIDGE CONTAINER FOR ASSEMBLY, MAINTENANCE, AND USE."

OSHA Cartridge Color Code

Contaminant	Color Coding on Cartridge/Canister
Acid gases	White
Hydrocyanic acid gas	White with 1/2 inch green stripe completely around the canister near the bottom.
Chlorine gas	White with 1/2 inch yellow stripe completely around the canister near the bottom.
Organic vapors	Black
Ammonia gas	Green
Acid gases and ammonia gas	Green with 1/2 inch white stripe completely around the canister near the bottom.
Carbon monoxide	Blue
Acid gases & organic vapors	Yellow
Hydrocyanic acid gas and chloropicrin vapor	Yellow with 1/2 inch blue stripe completely around the canister near the bottom.
Acid gases, organic vapors, and ammonia gases	Brown
Radioactive materials, except tritium & noble gases	Purple (magenta)
Pesticides	Organic vapor canister plus a particulate filter
Multi-Contaminant and CBRN agent	Olive
Any particulates - P100	Purple
Any particulates - P95, P99, R95, R99, R100	Orange
Any particulates free of oil - N95, N99, or N100	Teal

Respirator Failure Signs

WARNING SIGNS OF RESPIRATOR FAILURE

I. Particulate Air-Purifying

When breathing difficulty is encountered with a filter respirator (due to partial clogging with increased resistance), the filter(s) must be replaced. Disposable filter respirators must be discarded.

II. Gas or Vapor Air-Purifying

If, when using a gas or vapor respirator (chemical cartridge or canister), any of the warning properties (e.g., odor, taste, eye irritation, or respiratory irritation) occur, promptly leave the area and check the following:

- Proper face seal
- Damaged or missing respirator parts
- Saturated or inappropriate cartridge or canister

If no discrepancies are observed, replace the cartridge or canister. If any of the warning properties appear again, the concentration of the contaminants may have exceeded the cartridge or canister design specification. When this occurs an airline respirator or SCBA is required.

Respirator Failure Signs

WARNING SIGNS OF RESPIRATOR FAILURE

III. Service Life of Air-Purifying Respirator Canisters and Cartridges

The canisters or cartridges of air-purifying respirators are intended to be used until filter resistance precludes further use, or the chemical sorbent is expended as signified by a specific warning property, e.g., odor, taste, etc. New canisters, cartridges or filters shall always be provided when a respirator is reissued. When in doubt about the previous use of the respirator, obtain a replacement canister or cartridge.

IV. Supplied Air Respirator

When using an airlines respirator, leave the area immediately when the compressor failure alarm is activated or if an air pressure drop is sensed. When using an SCBA leave the are as soon as the air pressure alarm is activated.

Respirator Selection

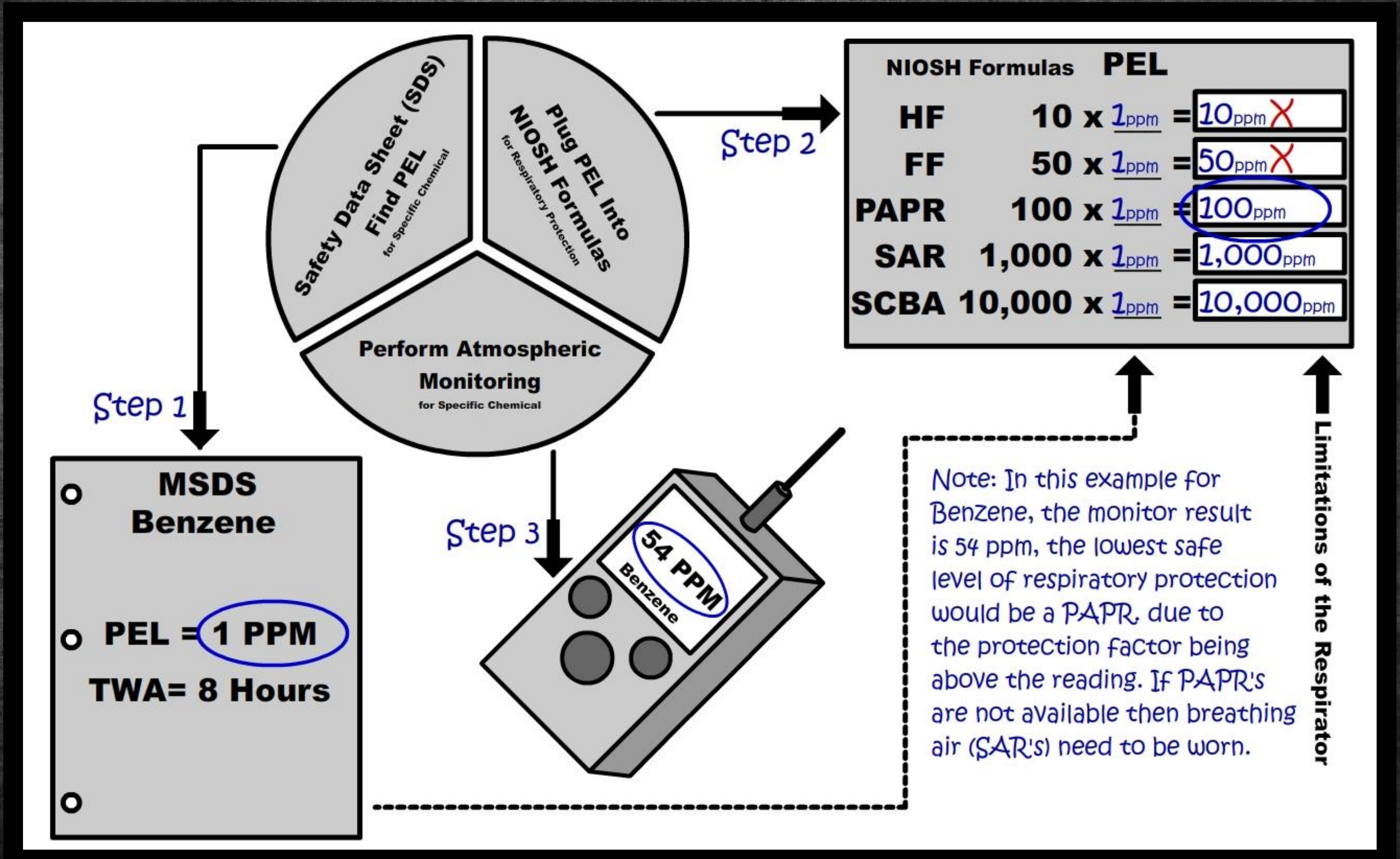
PROCESS OVERVIEW OF RESPIRATOR SELECTION:

1. Ascertain the PEL from the SDS of the chemical you are trying to protect yourself from.
2. Plug the PEL into the following NIOSH Formula to find the limitation of the respirator:

Half Face Negative-Pressure	HF	10 x PEL =	Limitation
Full Face Negative-Pressure	FF	50 x PEL =	Limitation
Full Face Positive Air Purifying Respirator	PAPR	100 x PEL =	Limitation
Full Face Supplied-Air Respirator	SAR	1,000 x PEL =	Limitation
Full Face Self Contained Breathing Apparatus	SCBA	10,000 x PEL =	Limitation

3. Monitor the area to determine the concentration of that chemical
4. Select the appropriate respirator with the limitation that supersedes the monitoring result.

Respirator Selection



Breathing Air Calculation

A human breathes volume, not pressure. Therefore, to calculate usable air by individuals or groups we must convert the pressure reading on the gauges to volume. The following formula converts PSI to Ft^3.

$X=Y(A-B)Z$

X = Volume of Air (This is what we are solving for)

Y = Number of Cylinders (6 Pack of breathing air would be 6 for example)

A = Regulator Pressure in PSI (equalize all the cylinders and look the gauge)

B = Reserve Pressure (Approximately 25% Cylinders air by Volume. On most Type G Cylinders this number is 500 PSI)

Z = Cylinder Divider (Requires knowing cylinder PSI when full and Volume of Cylinder When Full. The average Type G Cylinder is $300Ft^3$ at 2,400 PSI). Divide the Cubic Foot by the Pressure (300/2400=.125)

Breathing Air Calculation

Now plug in the numbers to the following formula:

$X=Y(A-B)Z$

Remember, Follow the Algebraic Order of Operations (PEMDAS)

- Parentheses
- Exponents
- Multiplication
- Division
- Addition
- Subtraction

Example: Lets say we have a 6-pack of breathing air that has 1,800 psi in all of the cylinders.

$X=6(1800-500).125$ $X=6(1300).125$ $X=7800x.125$ $X=975Ft^3$

Breathing Air Calculation

The result is 975 Cubic Foot of “usable” air. Remember, we had to remove 25% of the cylinders volume as a safety factor so we do not run out of air that is where the “usable” part comes from.

Now we must calculate our breathing rate.

On average, a human should breathe between 1.5 and 2.0 Ft^3 per minute. As a general rule (Unless I know the individuals breathing rate, from statistics) I always calculate using 2.0

As a side note and another guideline you should never have more than one person breathing off of one cylinder. So in this example, there should not be more than 6 people using the 6-pack of breathing air.

6 people breathing at 2 Ft^3 per minute = 12 Ft^3

Breathing Air Calculation

Now take the 975 Cubic Foot of "usable" air and divide it by the 12 Ft^3 per minute of consumption.

975/12=81.25

81.25 Minutes of air. That means a 6-pack of breathing air that has 1800psi will last 6-people with a breathing rate of 2.0 Ft^3 per minute:

1 Hour 21 Minutes and 15 Seconds.

Remember this is a decimal equation for time so here is a conversion chart to help:

Time Conversion Chart
(Minutes to Decimal Hours)

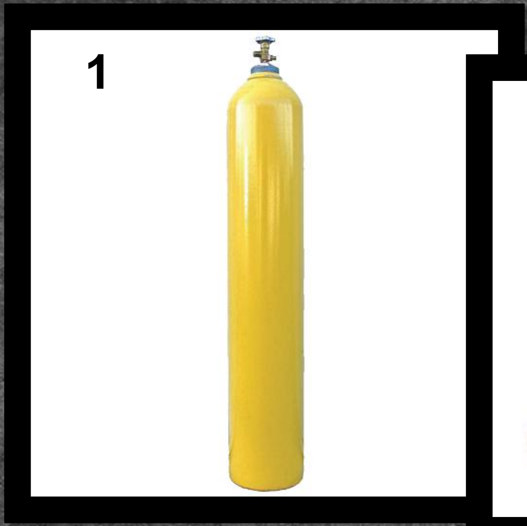
Minutes	Decimal Hours	Minutes	Decimal Hours	Minutes	Decimal Hours
1	.02	21	.35	41	.68
2	.03	22	.37	42	.70
3	.05	23	.38	43	.72
4	.07	24	.40	44	.73
5	.08	25	.42	45	.75
6	.10	26	.43	46	.77
7	.12	27	.45	47	.78
8	.13	28	.47	48	.80
9	.15	29	.48	49	.82
10	.17	30	.50	50	.83
11	.18	31	.52	51	.85
12	.20	32	.53	52	.87
13	.22	33	.55	53	.88
14	.23	34	.57	54	.90
15	.25	35	.58	55	.92
16	.27	36	.60	56	.93
17	.28	37	.62	57	.95
18	.30	38	.63	58	.97
19	.32	39	.65	59	.98
20	.33	40	.67	60	1.0

Supplied Air Set-up

Supplied Air Set-up

1. Place Breathing Air Cylinders uphill or upwind as close to the entry point as possible.
   - Usage should not exceed 1 person per cylinder
2. Connect High-Pressure Hose (OPTIONAL) to connect the regulator to the cylinders.
   - Try not to exceed 500ft of High-Pressure Hose
   - Verify that High-Pressure Hose has CGA-346 Fittings
3. Connect the Regulator with a low-pressure bell alarm to the cylinders.
   - Verify that the regulator and cylinders are CGA-346 Fittings
   - Tighten the regulator with an 1 1/8 inch wrench or only hand tight if it has a hand wheel.
4. Connect the Manifold (OPTIONAL) if multiple people are working off of the regulator
   - Only 8 people can operate per regulator
   - Do not use a manifold if only one person is wearing breathing air equipment
5. Connect Low-Pressure Hose to Regulator
   - Do not use more than 250ft of low pressure hose or 5 connections
6. Connect the Point of Attachment this could be a 5-minute or SCBA with hose line capabilities.

Emergency Egress Line



Emergency Egress Line (EEL) may be necessary for vessels that would be to large, deep or configured to egress with only 5-minutes of usable air.

The EEL would consist of the following:

- A separate (stand-alone) 300 ft^3 cylinder (or bank of cylinders) of breathing air
- A regulator with a low-pressure bell alarm
- A low-pressure hose suspended in the vessel at waist height to the rescuer

SCBA Checklist

1. Check gauge to see that the bottle is full
2. Check straps to see they are fully extended
3. Tighten shoulder straps so pack is sitting properly on the back
4. Tighten waist strap so pack is in place
5. Tighten chest strap (if provided)
6. Do a final tightening of face mask straps (chin, temple, top)
7. Do a fit test (cover hole on mask or end of the hose)
8. Completely open the flow valve

Energy Isolation

Energy Isolation

RESPONSIBILITY

Rescue Technicians shall be instructed in the safety significance of the Lockout / Tagout procedures, as well as how to use those procedures, by the Project Manager. Only authorized technicians may lockout or tagout machines or equipment. All authorized technicians shall be identified on each Hazardous Energy Control Form.

1. Affected technicians and any other technicians whose work operations are or may be in the affected area will be instructed in the purpose and use of the lockout / tagout procedures by the project manager.
2. Affected technicians or their job titles shall be identified on each Hazardous Energy Control Form. The authorized technicians will notify them whenever a lockout or tagout will occur, as well as when the equipment is being placed back in service.
3. It is the responsibility of each authorized technician to provide all Hazardous Energy Control Procedure Forms to the Project Manager.
4. The HSEQT Manager shall do an annual inspection of the lockout/tagout program to ensure that procedures and requirements are being followed.

Energy Isolation

PREPARATION FOR LOCKOUT OR TAGOUT

1. A survey shall be made to locate and identify all energy sources to be certain which switch, valve, or other energy isolating devices apply to the equipment to be locked or tagged out. More than one energy source (electrical, mechanical or others) may be involved. Findings of this survey will be documented on the Hazardous Energy Control Procedure Form, for the equipment or machine to be de-energized.
2. Identify all affected technicians by name or their job title that may be involved in the impending lockout / tagout.

Energy Isolation

LOCKOUT OR TAGOUT SYSTEM PROCEDURE

1. Notify all affected technicians that a lockout/tagout system is going to be utilized and the reason. The authorized technician shall know the type and magnitude of energy that the machine or equipment utilizes and shall understand the hazards.
2. Shut down the equipment by normal stopping procedures. Operate the equipment to ensure equipment is off.
3. Operate the switch, valve or other energy isolating device so that each energy source (electrical, mechanical, hydraulic, etc.) is disconnected or isolated from the equipment at the main disconnect. Stored energy such as that in capacitors, springs, elevated machine members, rotating fly wheels, hydraulic systems, air, gas steam or water pressure; must be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding, etc.
4. Authorized personnel shall lockout and tagout the energy isolating device with designated single keyed padlock and "DANGER - DO NOT OPERATE" tag. The tag shall contain: name of the authorized person and reason for isolation; a multi hasp device shall be affixed to the lock.

Energy Isolation

5. After ensuring that no personnel are exposed, and as a check on having disconnected the energy sources, the authorized person shall try to activate/start the equipment or machine at the remote push start button or other normal operating control to make certain equipment will not operate. CAUTION - return operating control(s) to “neutral” or “off” position after the test.
6. Each technician performing maintenance, servicing or cleaning activities on the de-energized machine or equipment shall then place his / her single keyed designated pad lock and tag (stating “DANGER - DO NOT OPERATE” with his / her name, date and reason) on the multi lock hasp.
7. Each craft / maintenance technician will physically try to activate the equipment at the remote start control prior to performing work activities.
8. Periodic inspections of the lockout/tagout system shall be completed by the on-site safety supervisor. A record of when the inspection was done should be written in the Daily Job Log.

Energy Isolation

GROUP LOCK OUT

1. In instances when numerous technicians will be performing work activities on a piece of equipment and the magnitude of locks would be impractical, a multi group lock may be utilized.
2. After isolation of the equipment by the authorized person, the Foreman in charge of the work task shall place his/her lock and tag on the multi hasp lockout device.
3. The Foreman shall then place the key in a designated lock box or cabinet.
4. Each technician performing work activities shall place his / her lock and tag to a multi hasp locking device to the lock box / cabinet controlling access to the Rescue Lead's key.

Energy Isolation

RESTORING EQUIPMENT TO SERVICE

1. After servicing and / or maintenance is complete, all tools have been removed, guards have been reinstalled and equipment is ready for normal production operation.
2. Each craftsman / service personnel shall remove his / her lock and tag.

NO TECHNICIAN WILL BE ALLOWED TO REMOVE ANOTHER TECHNICIANS LOCK OR TAG

3. The Rescue Lead shall inspect the machine or equipment to ensure all activities are complete and equipment is ready for service prior to removing his / her pad lock and tag.
4. The authorized technician shall check the area to ensure that no technician is exposed, prior to removing his / her lockout / tagout device and restoring energy to the machine / equipment.

Energy Isolation

EXTENDED WORK ACTIVITIES: will involve more than a single work shift

1. The authorized technicians locking device will stay affixed to the control / energy sources until job task is complete and system is to be re-energized.
2. Each craftsman / service person of the off going shift shall remove his / her pad lock and tag, as the oncoming shift at the beginning of the next working day reapplies their locks and tags.

EXTENUATING REMOVAL OF LOCKS

1. Any technician transferred to another task / assignment and no longer working with / on the equipment / machine involved shall remove his lock and tag upon transfer.
2. In a case where an technician has inadvertently left his / her lock and tag in place and work activities are complete or key is lost.
3. The Rescue Lead shall make every attempt to locate the individual or key for removal.
4. If the technician / key cannot be located; the Project Manager shall assure equipment is ready to be placed in service.
5. The Project Manager shall be present at physical removal of said lock.

Ventilation

Ventilation

In OSHA's confined space standard 29 CFR 1910.146, they do not specify how many air exchanges must be circulated per hour. Some state laws require a minimum air exchange amount of 6 times per hour, but that number is by no means universal.

A common rule of thumb has always been 5 complete air exchanges prior to entry and at least that per hour during entry. There are other experts who advocate 7 or 10 complete changes before work begins. Some manufacturers of ventilation products recommend 20 air exchanges just to be on the safe side, but the best way to determine safety for your particular space is by performing a complete and accurate atmosphere evaluation with proper instrumentation.

In practice, ventilate for as long as possible before entry, and those who plan their days well often set up the equipment and get it fired up far in advance of the scheduled work. Ongoing monitoring of the space using a monitor allows entrants to make sure the atmosphere stays safe.

Ventilation

1. Use the applicable geometric shape formula to get the volume (estimated volume) of the space. – Example: **L x W x H for a Rectangle (measured in feet)**
2. Multiply that volume by the number of times you want to change out the space – Example: **6 Times per hour**
3. Find out the cfm (Cubic Foot per Minute) of the Air Mover in which you are going to use. – Example: **2,000 CFM**
4. Calculate using 80% of the air mover's capabilities (to calculate for loss due to shape of space, pneumatic deficiencies, power surges or load, manway restrictions, etc.) – Example: **2,000 x 80% = 1,600**
5. Divide the total volume from step 2 by step 4. This will give you the minutes it takes to exchange that volume.

L=20ft W=15ft H=60ft – Volume = 18,000ft^3

18,000ft^3 x 6 = 108,000ft^3

108,000ft^3 / 1,600cfm = 67.5 minutes

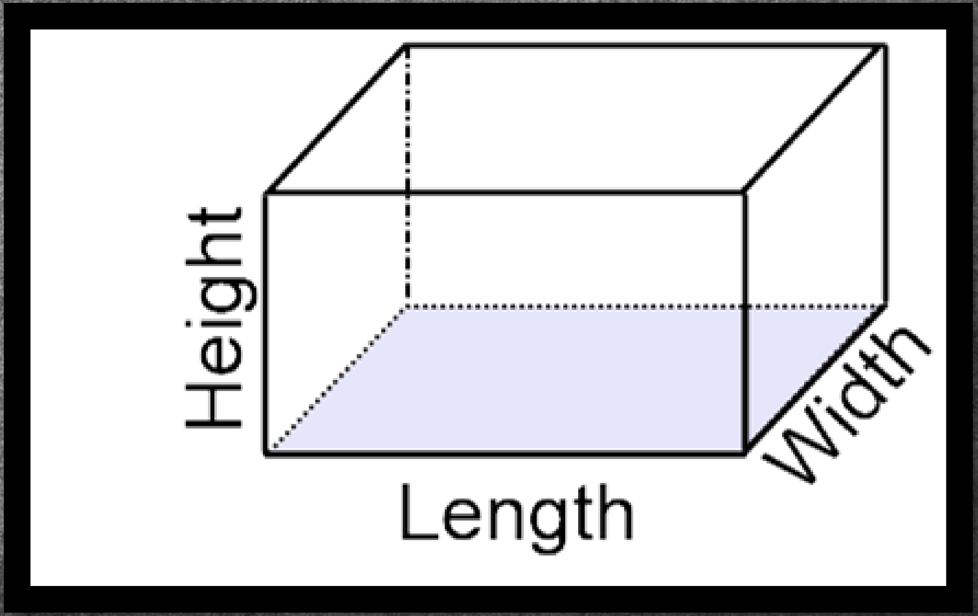
Since the answer is greater than 60 (minutes of air) then 2 air movers should be used to achieve at least 6 times per hour. Further reduce risk by using 1 pneumatic and 1 electric in case of source failure - Redundancy

Ventilation

Volume of a Rectangle

To find the volume of any rectangle you need to know the length, width and height. The formula to find the volume multiplies the length by the width by the height.

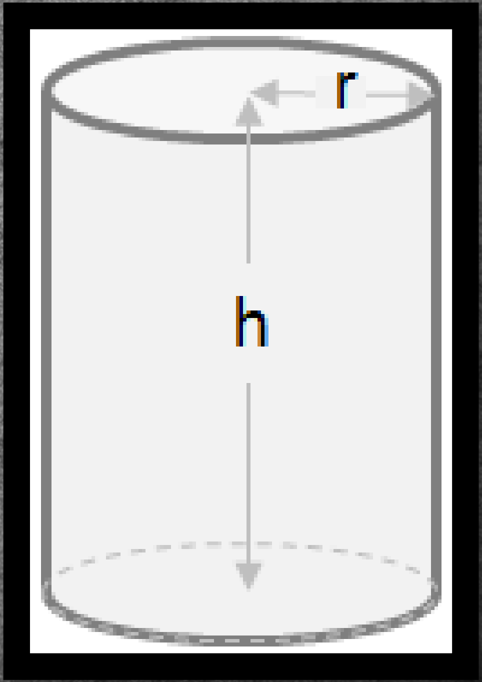
Volume = L x W x H



Ventilation

Volume of a Cylinder

Calculating the volume of a cylinder involves multiplying the area of the base by the height of the cylinder. The base of a cylinder is circular and the formula for the area of a circle is: area of a circle = πr^2 . There is more here on the area of a circle.



cylinder with height and radius marked
Volume = Area of base x Height

Volume = πr^2 x h

Volume = πr^2 h

Ventilation

Ventilation Types:

Decontamination

Decontamination

"Decontamination" means the removal of hazardous substances from employees and their equipment to the extent necessary to preclude the occurrence of foreseeable adverse health affects.

Decontamination:

1. General: Procedures for all phases of decontamination shall be developed and implemented in accordance with this paragraph.

2. Decontamination procedures.
   i. A decontamination procedure shall be developed, communicated to employees and implemented before any employees or equipment may enter areas on site where potential for exposure to hazardous substances exists.

   ii. Standard operating procedures shall be developed to minimize employee contact with hazardous substances or with equipment that has contacted hazardous substances.

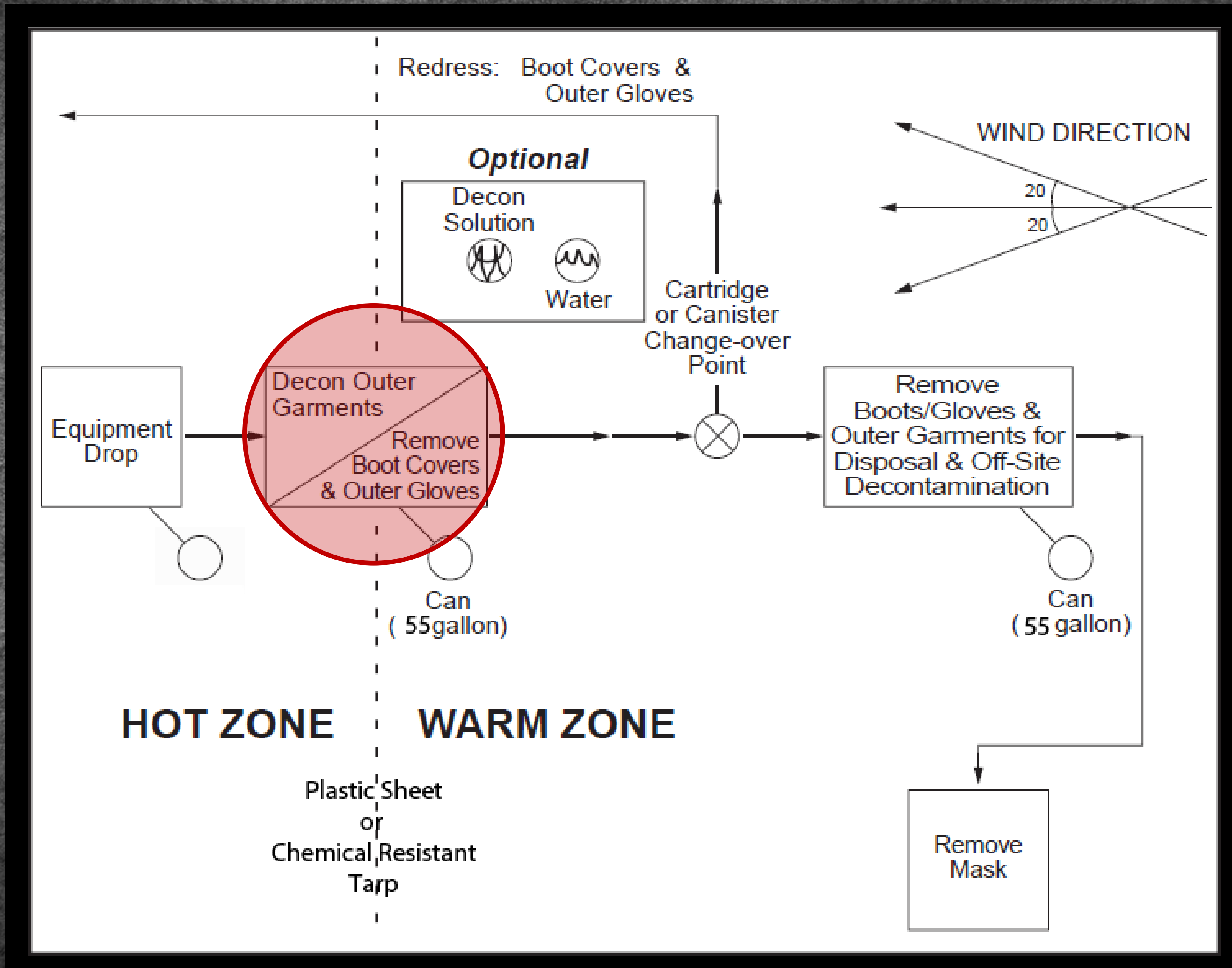
Decontamination

iii. All employees leaving a contaminated area shall be appropriately decontaminated; all contaminated clothing and equipment leaving a contaminated area shall be appropriately disposed of or decontaminated.

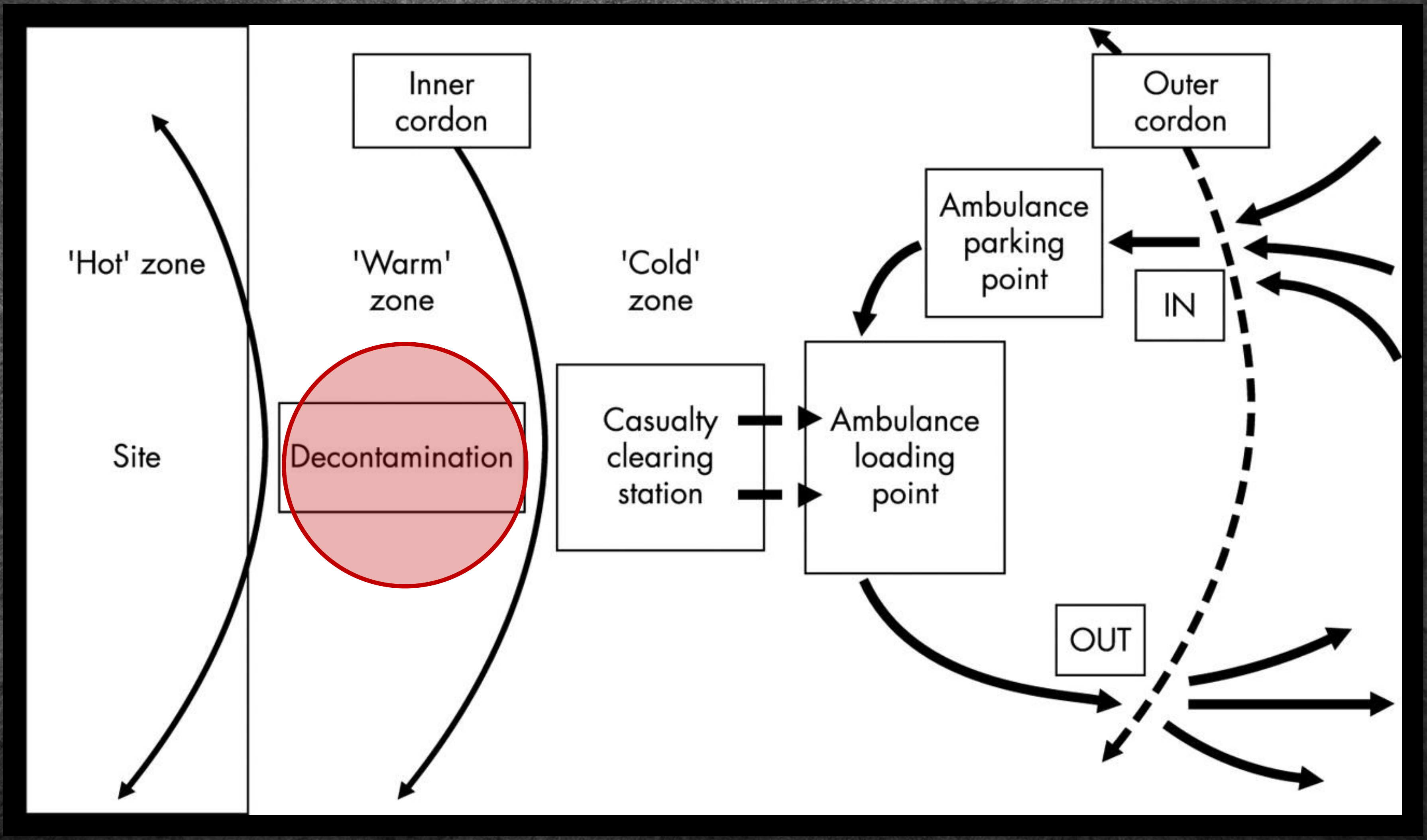
iv. Decontamination procedures shall be monitored by the site safety and health supervisor to determine their effectiveness. When such procedures are found to be ineffective, appropriate steps shall be taken to correct any deficiencies.

3. Location: Decontamination shall be performed in geographical areas that will minimize the exposure of uncontaminated employees or equipment to contaminated employees or equipment. The next two pages show examples of more complex decontamination procedures or areas that may need to be set up.

Contamination Reduction Zones



Contamination Reduction Zones



Decontamination

4. Equipment and solvents. All equipment and solvents used for decontamination shall be decontaminated or disposed of properly.

5. Personal protective clothing and equipment.
   i. Protective clothing and equipment shall be decontaminated, cleaned, laundered, maintained or replaced as needed to maintain their effectiveness.

   ii. Employees whose non-impermeable clothing becomes wetted with hazardous substances shall immediately remove that clothing and proceed to shower. The clothing shall be disposed of or decontaminated before it is removed from the work zone.

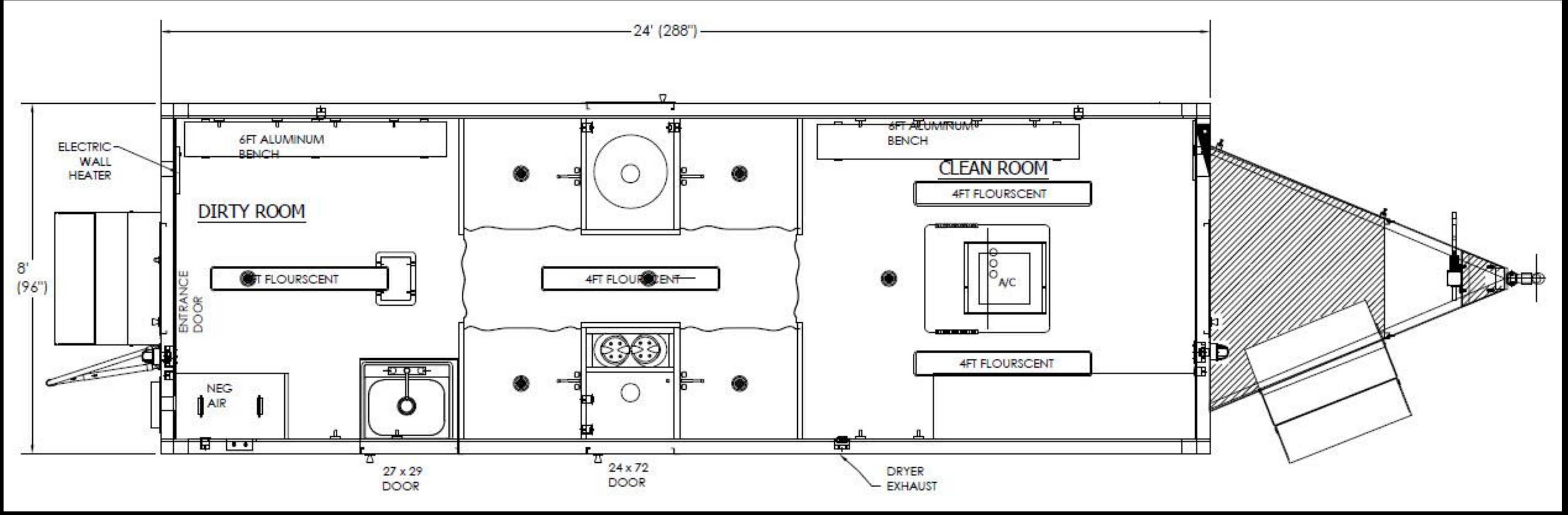
6. Unauthorized employees. Unauthorized employees shall not remove protective clothing or equipment from change rooms.

Decontamination

7. Commercial laundries or cleaning establishments. Commercial laundries or cleaning establishments that decontaminate protective clothing or equipment shall be informed of the potentially harmful effects of exposures to hazardous substances.

8. Showers and change rooms. Where the decontamination procedure indicates a need for regular showers and change rooms outside of a contaminated area, they shall be provided and meet the requirements of 29 CFR 1910.141. If temperature conditions prevent the effective use of water, then other effective means for cleansing shall be provided and used.

Decon Trailer



Simple Decon Stations

Heat Stress

Heat Stress

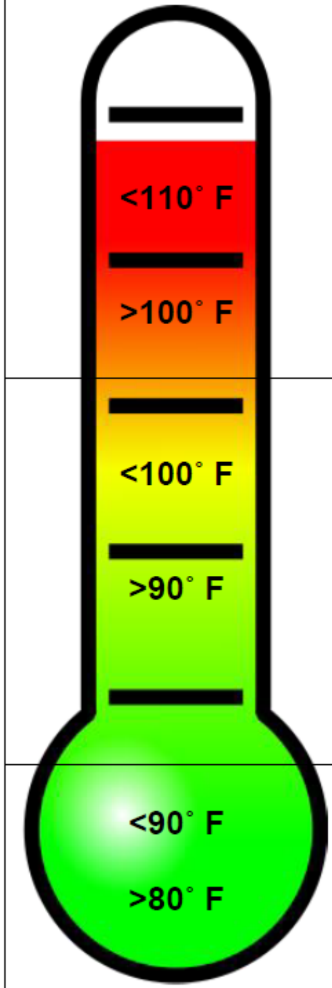
Heat stress generally describes the effect of heat, from any source, on the organs of the body and the person as awhile. The stresses of heat on the body manifest themselves in five common ailments:

- heat exhaustion
- heat cramps
- heat stroke
- heat syncope
- heat rash

Different parts of the country and world have different environmental conditions, which affect this generic standard Local practices; average temperatures, and common working habits should be considered.

Once heat levels become higher than 95°F for whatever reason (natural weather conditions or mechanical heat sources), the rescue lead should instruct his/her safety advisor or request assistance to develop a heat stress management plan for the project. The following Heat Advisory Chart should help in the development of a Heat Stress Management Plan in most scenarios.

Heat Advisory Chart



ADVISORY LEVEL	NORMAL PPE	ADDITIONAL PPE
III	Fluids – Every Hour (Recommended) Temp. Inside Confined Space Cannot Exceed 100˚ F – (Mandatory) Implement at Least One of the Following: Nitrogen (Cooled) External Cool Device (AC) Personal Cool Device (Cool Vest) Rotate Personnel, Buddy System/Add to Work Team Plan Work at Cooler Time of Day (If Possible)	• Heat Stress Prevention Plan Required • Fluids – Every 20 Minutes (Mandatory) • Temp. Inside Confined Space Cannot Exceed 100˚ F – (Mandatory) • Consider Alternate Work Plan • Implement at Least <u>Two</u> of the Following: External Cool Device (AC) Personal Cool Device (Cool Vest) Rotate Personnel, Buddy System/Add to Work Team Plan Work at Cooler Time of Day
II	• Fluids – Every Hour (Recommended) • Rest Breaks – Every 2 Hours (Recommended) • Cool Device - (Optional)	• Fluids – Every Hour (Recommended) • Temp. Inside Confined Space Cannot Exceed 100˚ F – (Mandatory) • Implement at Least <u>One</u> of the Following: Nitrogen (Cooled) External Cool Device (AC) Personal Cool Device (Cool Vest) Rotate Personnel, Buddy System/Add to Work Team Plan Work at Cooler Time of Day (If Possible)
I	• Fluids - Maintain Adequate Hydration • Rest Breaks – Self Pace • Cool Device – (Optional)	• Fluids – Every Hour (Recommended) • Rest Breaks – Every 2 Hours (Recommended) • Cool Device – (Optional)

Heat Stress

The plan should contain the following data:

- Temperatures expected to be found in the work place based upon environmental factors such as air temperature, relative humidity, air velocity, and thermal radiation
- Based upon temperatures found, a ration of work time versus rest periods, with work periods reducing while rest periods increase as temperature rises.
- A medical monitoring program for those people exposed to heat stress and those highly susceptible to heat stress (the obese, unacclimatized workers, workers with cardio circulatory diseases, and employees who may take medications or the heavy use of alcohol.
- The plan should include a cooler than ambient temperature rest location, delivery of iced drinking, and a plan for replenishment of salt within the body.

Heat Stress

- An emergency plan for handling heat stroke and severe heat exhaustion.
- A plan to engineer out the sources of heat by shielding, insulation, or mechanical methods of reducing heat or increasing air velocity.

Appendix A

Glossary

Glossary

- Accessory Cord – Any low-stretch cordage [rope] made from nylon, Spectra, or Kevlar fibers and used for any number of purposes. Generally, any cord smaller than 9mm is considered an accessory cord.
- Active Protection – Rock climbing protection (camming devices) which have moving parts as part of the camming mechanism. Spring-loaded camming devices are considered "active".
- Air Monitoring – Those actions needed to insure atmospheric safety during a confined space emergency through the use of specialized monitoring equipment. Air monitoring is the single most important diagnostic tool used in making a confined space emergency atmospherically safe. Ventilation is the prescribed treatment. Air monitoring must continue during the full extent of the rescue and must work in harmony with the ventilation sector. The areas of primary concern are:
  1. The opening of the space.
  2. The source of air being supplied to the space.
  3. The air being drafted from the space.
  4. The interior of the space (personal monitors on the entry team).
- Anchor – Any means of attaching the rope to an object. It may be a natural anchor such as a tree or rock formation, or an artificial anchor provided by the rescuer, such as a bolt or rock protection.

Glossary

- Anchor Types:
  - Single Point Anchors:
    - Anchors that originate from one location, such as a pole, tree, bolt, etc. A single point anchor may be bombproof or may be a marginal component of an anchor system.
  - Tensioned Anchors:
    - Anchors working in harmony by virtue of a back-tie system.
- Hard Ascender – Hardware camming devices which grip the rope in one direction.
- Belay System – Protection against a fall by handling a secondary unloaded rope (belay rope) in such a manner that is may be taken in or let out yet can be secured to hold this load in case of failure of the working line or rappel line.
- Bolt – Artificial, reliable means of anchoring in rock requiring the drilling of holes and the placement of bolts.
- Brake Rack – A friction device used for rappelling or the safe control of lowering systems. Typically, the brake rack employs multiple friction bars held in place by a steel frame. The friction bars are capable of collapsing or loosening around the rope, therefore providing the needed friction for the safe control of the descent.
- Carabiners – Hardware used for the purpose of connecting any two points of a given rope system. Carabiners typically employ a self-closing, gate as apposed to other connecting hardware that employ manually operated screws that close the opening, see screw-links and tri-links.

Glossary

- Change of Direction Pulley – A change of direction is a pulley on the anchor that directs the last leg of rope to the haul team, notated (cd).
- Compound Mechanical Advantage Pulley System – Any pulley system that is made up of two or more simple pulley systems. Example; a compound 6:1 could be a 3:1 pulling on the end of a 2:1, or a 2:1 pulling on a 3:1. The simple components are multiplied to give the compound mechanical advantage.
- Cordelettes – Typically, a small rope, typically 8 mm or 9 mm, and approximately 10 meters long, used for rigging. Example; small pulley systems, whipping and frapping, etc.
- Critical Point Test – A test rescue teams use to determine the inherent safety within a rope rescue system. In order to pass the Critical Point Test, a system must have no point or single piece of equipment which, were it to fail, would cause catastrophic failure of the entire system.
- Directional Pulley – A directional is a pulley or pulleys between the pulley system and the load to be raised, notated (CD) or (1:1)
- Dynamic System Safety Factors – (Movement and maximum system stress, with a suspended load) the ratio between the load and the weakest link in a system using the rated breaking strength of each piece of equipment in the system and a theoretical prediction of those factors that will add maximum stress to the system. For instance, any part of a given system will only hold 6000 lbs. and the work being placed on the system is 1000 lbs, including approximately 20’ of rope drag at or over the edge, will in effect double the weight of the load on a raising system. The Safety Factor would then be approximately only a 3:1. A 7:1 Dynamic System Safety Factor is a realistic goal when a belay rope is present.

Glossary

- Ganged Mechanical Advantage Pulley System – When a separate rope used for a MA system is attached by a haul grab to another MA system for the purpose of lifting or lowering a load.
- Hardware – Those components of a rope system that are made of metal.
- Haul Field – The haul field is the available distance a hauler or haulers can run out or the space that they have to stand and pull.
- High Directional – A means of suspending a loaded rope at least 2 meters above the edge so that edge trauma is reduced. There are structural, natural and artificial high directionals.
- Horizontal Systems – Any adjunct rope system that is employed for the purpose of changing the original direction of the mainline and belay line systems.
- Loaded Changeover – Those actions needed to convert the mainline from a lowering system to a raising system while the load is suspended and under tension.
- Litter – A device used to contain a patient and maintain stability during the extrication process.
- Lockout/Tagout – Those actions needed to bring all potential hazards, typically electrical, mechanical, and engulfment, to a neutral state prior to the beginning of any rescue.
- Mainline – Also known as the Working Line, it is the main rope system used to do the lowering and raising of the rescue package.
- Mechanical Advantage – The increase of the input of power for the purpose of moving objects, typically during rope rescues, this would most often include the use of pulley systems.

Glossary

- Multipoint Anchor System – Any combination of point anchors that are employed to make one reliable anchor. The following are the two major divisions of multipoint anchor systems:
  1. Self Distributing: (Also known as Self-equalizing) A multipoint system rigged to where the force of the load is distributed between all the point anchors. Due to friction and many other unseen factors, this distribution is not as equal as most would assumed.
  2. Fixed Multi-point: (Also known as "Load Sharing") A multipoint anchor system which is distributing during the construction of this anchor and is than fixed into place, typically by virtue of an overhand loop.
- Passive Protection – Rock climbing protection which has no moving parts (as opposed to active protection, which does). Examples are stoppers, hexcentrics, and tri-cams.
- Patient Packaging – Patient packaging is the act of getting the patient ready to be evacuated.
- Personal Loads – Any load equal to a single person.
- Piggyback – A piggyback system is a compound MA that is made up of two or more identical simple MA's. i.e. a compound 4:1 (2:1)(2:1). Or a MA system added to a load line
- Pulleys – A small grooved wheel used with a rescue rope to change the direction and point of application of a pulling force. They may be used in combinations to employ mechanical advantage especially for the purpose of a raising operation.
- Rappelling – The act of descending a fixed rope system in a controlled manner for the purpose of vertical transportation.
- Ratchet – A progress capture device employed for the sole purpose of holding the load in place during the reset phase of a raising operation.

Glossary

- Reset – Action taken to re-extend the pulley system for another haul after it has fully collapsed during a raising operation.
- Rescue Load – As determined at the Forth Annual Technical Rescue Symposium, 1987, a rescue load is considered to be 200 Kg, 448 lbs. It is the weight of one victim/patient, one rescuer, and associated gear.
- Risk/Benefit Analysis – A command decision that determines the type of action needed based on the hazards present and the risk they pose to the team and the victim.
- Rope – Typically, kernmantle rope is the most common rope used for rescue operations. (Because of its floating properties polypropylene is sometimes used in swiftwater rescue.) Kernmantle rope is constructed of a load-bearing core, or "kern", of nylon fibers surrounded by a braided, protective outer sheath, or "mantle". The core is completely protected by the mantle and holds most of the load. It has a high strength to weight ratio, and maintains most of its strength when wet (approximately 85%). Kernmantle rope comes in two types; Dynamic and Static.
- Dynamic Rope – Consists of twisted or bundles that make up the core. This twisted core provides a high stretch quality. This allows as much as 40% stretch in the rope, depending on the manufacturer. Dynamic rope is very important in rescue work solely for the purpose of belaying a lead climber.
- Static Kernmantle Rope – stretches very little, from 2-4% under load. This type of rope is made from an outer braided sheath (mantle) which is woven over straight nylon fiber core (kern). The core supports 85% of the rope's strength. "Static" kernmantle rope is used for rigging rescue system because of its high strength, low stretch and handling characteristics.

Glossary

- Rope Grabs – Any device attached to a rope for the purpose of holding or grabbing, may be software or hardware.
- Screw-links – Hardware connectors that employ a manually operated screw to close and open the gate.
- Size-up – The initial evaluation of the emergency scene by the first responder.
- Soft Ascenders – Any number of rope hitches which grab the rope in one or both directions.
- Software – Any rope system component that is either rope, webbing, or is constructed of rope or webbing.
- Static System Safety Factor – In a static state, (no movement, with a suspended load) the ratio between the load and the weakest link in a system using the rated breaking strength of each piece of equipment in the system. For instance, any part of a given system will only hold 5000 lbs. and the work being placed on the system is 1000 lbs.. The Safety Factor is then 5: 1. A 10: 1 Static System Safety Factor is a realistic goal when a belay rope is present.
- System Loads – See "Rescue Loads".
- Throw – The throw is the available distance between maximum pulley system extension and the need for a reset.
- Tri-links – Triangle shaped, hardware connectors that employ a manually operated screw to close and open the gate. Tri-links are particularly suited for multiple loading in multiple directions. Also referred to as Delta Links.

Glossary

- Webbing – Widely used by rock climbers and rope rescuers, webbing is a flat nylon software that is relatively inexpensive and extremely strong. Although webbing has multiple uses, it is particularly suited for anchor rigging.
- Working Line – Also know as "the mainline", the working line is the main support rope for the rescue operation.
- Working Load Limit – A rating that is sometimes used in conjunction with hardware, typically screw-links and tri-links.

Appendix B

Acronyms

Acronyms

ACLS	Advanced Cardiac Life Support
AHD	Artificial High Directional
ALS	Artificial Life Support
ANSI	American National Standards Institute
APR	Air Purifying Respirators
AZTEK	Arizona Technician Edge Kit
BA (B/A)	Breathing Air
BLS	Basic Life Support
C6H6	Benzene
CD	Change Direction
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CPR	Cardiopulmonary Resuscitation
CRZ	Contamination Reduction Zone
DECON	Decontamination
DOT	Department of Transportation
EPA	Environmental Protection Agency
FF	Full Face
GFCI	Ground Fault Circuit Interrupter

Acronyms

Haz-Com	Hazard Communication Standard - 29 CFR 1910.1200
HAZWOPER	Hazardous Waste Operations and Emergency Response - 29 CFR 1910.120
H2S	Hydrogen Sulfide
H2SO4	Sulfuric Acid
HD	High Directional
HF	Half Face
IDLH	Immediately Dangerous to Life and Health
LC50	Lethal Concentration 50%
LD50	Lethal Dose 50%
LEL	Lower Explosive Limit
kN	Kilo Newton: equivalent to 225 pounds force
MA	Mechanical Advantage
mcg/m3	Micrograms per Cubic Meter
mg/m3	Milligrams per Cubic Meter
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air Purifying Respirator

Acronyms

PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PPM	Parts Per Million
PPB	Parts Per Billion
PPT	Parts Per Trillion
PPTh	Parts Per Thousand
PVC	Polyvinyl Chloride
SO2	Sulphur Dioxide
SADT	Self Accelerating Decomposition Temperature
SAR	Supplied Air Respirator
SCBA	Self Contained Breathing Apparatus
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
TLV	Threshold Limit Value
TWA	Time Weighted Average
UEL	Upper Explosive Limit

Acknowledgment

Acknowledgment

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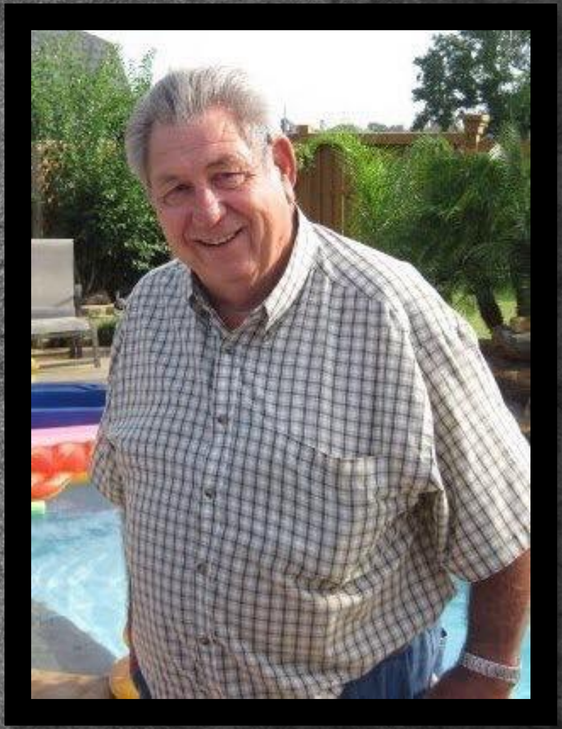
Dedication

Although, this is truly a collection of work over my last 25-years in the business, and I have had an opportunity to learn from the best in the industry, many of the opportunities I have had have been due to my Dad. Not only has been a father and an employer, he has been my confidant and most of all my friend. He taught me many things throughout the years, most of all he had the patience to coach, push and mentor me so I could be the best that I could possibly be.

When he passed away in 2012, I received countless phone calls from all over the country within hours of his passing. The most incredible thing I repeatedly heard was how much he meant to all the guys that had worked with him over his career. Not only had we lost a great man, we had lost a brother and a father figure to many of us in this industry. I love you Dad, as I am sure many others do, and this collection of work is for you, so you may still carry on.



Dale Torrans
December , 23rd 1941
August, 20th 2012

About the Author

Shayne Torrans has over twenty-seven years of experience in the petrochemical industry. Positions held have included Director of Safety and Health, SHEQT Manager, Training Manager, Safety Supervisor, Industrial Hygienist, Haz-Mat Specialist, Incident Commander, Rescue Team Leader, Breathing Air Specialist and Environmental QA/QC Analyst.

He is certified in over 40 “Train-the-Trainer” industrial subjects and has taught thousands of people over his career. As a subject matter expert in Structural, High-Angle, Confined Space, Inert and Highline rescue, many have relied on his expertise during legal cases as well as the operational execution of high-risk work all over the world.

Shayne’s passion in rigging and rescue stems from his early climbing years in Wyoming, Colorado, Utah and Texas.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