M100 M14 L11
A Study Guide to Sling Arrangements and Safety

Chapter 1: Foundational Principles of Rigging Safety

1.1 The Core Tenets: Load, Environment, and Equipment

The safe execution of any lifting operation is governed by a triad of fundamental, interacting variables: the load, the environment, and the equipment. A failure to comprehensively analyze any one of these components invalidates the safety of the entire system. These are not sequential checklist items but rather the inputs to an interdependent decision matrix. The selection of appropriate rigging is not a simple choice but a deduction derived from the constraints imposed by these three elements.

The process begins with a thorough understanding of the load. This extends beyond merely knowing its weight. The operator must confirm the precise weight and locate its center of gravity to ensure a stable lift.[1] The load's physical dimensions, shape, and the presence or absence of designated lifting points will dictate the type of hitch required. Furthermore, the load's surface characteristics are a critical consideration. A load with sharp, unyielding edges can sever a synthetic sling, necessitating the use of edge protection or a more durable sling material like chain or wire rope.[1] Conversely, a load with a delicate or highly finished surface may be damaged by the hardness of a chain sling, making a synthetic web sling the more appropriate choice.[3]

Concurrent with the load analysis is an assessment of the operational environment. Ambient conditions can severely limit the types of equipment that can be safely deployed. Temperature is a primary constraint; synthetic slings, for example, have a limited operational range, typically from -40°C to 90°C (-40°F to 194°F), and are unsuitable for high-heat applications where alloy steel chain slings excel.[5] The presence of chemicals is another critical factor. Different synthetic materials have distinct chemical resistances; nylon slings are damaged by acids but resist alkalis, whereas polyester slings are damaged by alkalis but resist many acids.[6] An incorrect material choice in a chemically active environment can lead to rapid, unseen degradation and catastrophic failure. Physical constraints of the environment, such as limited headroom, also influence the rigging plan, as they can restrict the achievable sling angle, which has profound implications for sling tension.[7]

Only after a complete analysis of the load and environment can the correct equipment be selected. This selection encompasses not just the sling but all associated hardware, such as hooks, shackles, and links. Every component in the lifting assembly must have a rated capacity appropriate for the forces it will experience during the lift, which includes the tension generated by sling angles.[1] The final rigging plan is therefore a synthesis of these analyses—a solution that is compatible with the load's physical properties, resilient to the environmental conditions, and robust enough to handle the dynamic forces of the lift. The decision-making process is not linear. For instance, an environment with high heat may mandate an alloy chain sling.[8] This choice, in turn, influences how the load must be handled, as the chain may damage the load's surface, requiring protective padding. This demonstrates the interconnected nature of the decision matrix, where a constraint in one domain imposes requirements on the others.

1.2 Anatomy of a Sling Tag: Deciphering WLL and Material Grade

The identification tag affixed to a lifting sling is the most critical source of safety information for the operator. It is a legal and operational requirement under Occupational Safety and Health Administration (OSHA) standards; a sling that has a missing or illegible identification tag must be immediately removed from service.[9] This tag is not merely a label but a formal declaration by the manufacturer of the sling's identity, capabilities, and operational limits, in accordance with standards such as those from the American Society of Mechanical Engineers (ASME).[11]

Visually, the tag is a durable component, often made of metal or a resilient polymer, designed to withstand the rigors of the industrial environment and remain legible throughout the sling's service life.[13] It is permanently attached to the sling, typically near an eye or fitting. The information presented on the tag is standardized and non-negotiable. It must state the name or trademark of the manufacturer, the sling's size or diameter, and the material from which it is constructed.[14] For alloy steel chain slings, this includes the material grade, with Grade 80 and Grade 100 being the most common for overhead lifting.[5]

Most importantly, the tag specifies the sling's Rated Load, also known as the Working Load Limit (WLL). This is the maximum mass or force that the sling is certified to handle under specific configurations. The WLL is not a single value but is listed for the three primary hitch types: a vertical hitch, a choker hitch, and a basket hitch.[5] For multi-leg bridle slings, the tag will also provide the rated capacity at specific, critical sling angles. For example, a tag on a two-leg bridle might state a WLL of 7,400 lbs at a 60-degree horizontal angle, and a lower capacity at a 45-degree angle.[16] This detailed information is essential because, as will be discussed, the hitch type and sling angle dramatically alter the forces experienced by the sling.

The sling tag should be understood as a binding contract of performance between the manufacturer and the user. It certifies that the sling, when new and undamaged, can safely handle the specified loads under the exact conditions listed. Any deviation from these parameters—such as exceeding the WLL, using the sling at a shallower angle than rated, or continuing to use a damaged sling—constitutes a breach of this operational contract.[9] Such actions introduce unquantified and unacceptable risks into the lifting operation, rendering it non-compliant with safety standards and dangerously unpredictable. The rigger's first action before using any sling must be to locate, read, and understand the information on its tag.

1.3 Sling Material Analysis: Chain vs. Wire Rope vs. Synthetic

The selection of a sling material is a critical engineering decision that involves balancing a series of competing properties. No single material is optimal for all applications; instead, the choice represents a trade-off among durability, load protection, and ease of handling. Understanding the distinct characteristics of the three primary material categories—alloy steel chain, wire rope, and synthetic webbing—is fundamental to selecting the correct tool for a given lift.

Alloy steel chain slings are defined by their exceptional durability and strength. They are the preferred choice for lifting in harsh environments, such as foundries and steel mills, due to their superior resistance to abrasion, crushing, and cutting.[4] They also possess a significant advantage in high-temperature applications, capable of operating at temperatures up to 205°C (400°F) with no reduction in capacity for common grades like 80 and 100.[5] Uniquely among sling types, alloy chain slings are repairable; a damaged link can be replaced by a qualified person and the sling can be re-certified for service, which can be cost-effective over its lifespan.[7] However, these advantages come with significant drawbacks. Chain slings are extremely heavy, making them difficult to handle manually, and their weight increases substantially with higher capacity ratings.[3] Their hard, unyielding surface can easily scratch, crush, or otherwise damage sensitive or finished loads.[4]

Wire rope slings represent a compromise between the brute strength of chain and the flexibility of synthetics. Constructed from steel wires twisted into strands around a core, they offer high strength and flexibility in a relatively small diameter.[4] The core's material—either a fiber core for greater flexibility or an Independent Wire Rope Core (IWRC) for greater strength and heat resistance—allows for some customization of its properties.[14] Wire rope is more abrasion-resistant than synthetic slings and lighter than chain slings of similar capacity.[4] However, it is vulnerable to damage from kinking, crushing, and "bird caging" (a condition where the outer strands unravel and form a cage-like shape).[14] It is also susceptible to internal and external corrosion, and unlike chain, a damaged wire rope sling is not repairable and must be removed from service and destroyed.[4]

Synthetic slings, made from materials like nylon or polyester, are at the opposite end of the spectrum from chain. Their primary advantages are that they are lightweight, extremely flexible, and non-marring, making them the ideal choice for lifting delicate or highly finished equipment that could be damaged by metal slings.[3] Their flexibility allows them to conform closely to the shape of a load, providing a secure grip.[6] Furthermore, they are non-conductive and non-sparking, a critical safety feature for use in potentially explosive atmospheres.[4] The major limitation of synthetic slings is their vulnerability. They are easily cut by sharp edges and have poor resistance to abrasion.[3] They are also susceptible to damage from high temperatures, prolonged exposure to UV radiation from sunlight, and specific chemicals.[3]

This comparison reveals a clear pattern of engineering trade-offs that can be visualized as a triangle with vertices labeled "Durability," "Load Protection," and "Ease of Handling." Selecting an alloy chain sling maximizes durability but minimizes load protection and ease of handling. Selecting a synthetic sling maximizes load protection and handling but minimizes durability. Wire rope occupies a middle ground. The rigger's task is to analyze the specific requirements of the load and environment to determine the optimal balance point within this trade-off triangle.

1.4 The Non-Negotiable Pre-Use Inspection

The routine inspection of rigging equipment is the foundational practice of lifting safety. It is mandated by both OSHA and ASME standards, which require that a competent person visually inspect every sling and all associated hardware prior to each use or, at a minimum, at the beginning of each work shift.[1] This is not a cursory glance but a tactile, systematic examination of the entire piece of equipment to identify any signs of degradation or damage that could compromise its integrity under load.

The purpose of this pre-use inspection is predictive, not post-mortem. It is not an exercise to determine why a failure occurred, but rather a diagnostic process to identify the leading indicators of potential failure before a load is ever suspended. Material handling equipment rarely fails without warning. Damage is typically progressive, and the pre-use inspection is the primary tool for detecting it in its early stages. A broken wire, a cut in webbing, or a stretched chain link is not just a flaw; it is a critical data point indicating that the sling's load-bearing capacity has been compromised and its failure under its rated load is now a quantifiable probability.[1]

The inspection criteria are specific to the sling material. For an **alloy steel chain sling**, the inspector must look for any signs of wear, nicks, cracks, gouges, or stretched links. Discoloration is a key indicator of heat damage, which can alter the heat treatment of the alloy and reduce its strength.[5] The throat opening of hooks must also be measured to check for spreading, which indicates overloading. For a **wire rope sling**, the inspection involves looking for broken wires, severe abrasion, kinking, crushing, or any other damage to the rope's structure, such as the "bird caging" deformation.[14] Corrosion, both internal and external, is another critical sign of degradation. For **synthetic slings**, the inspector must be vigilant for any cuts, tears, snags, or holes in the webbing. Other signs of damage include broken or worn stitching, excessive abrasive wear, and damage from heat or chemicals, which can manifest as melted or charred areas, discoloration, or increased stiffness of the material.[6]

If any of these defects or any other condition that casts doubt on the sling's continued safe use is discovered, the sling must be immediately removed from service.[1] It should be tagged with an "Out of Service" label to prevent accidental reuse. A qualified person must then determine if the sling can be repaired (a possibility only for chain slings) or if it must be permanently destroyed to prevent its re-entry into service.[1] This rigorous, disciplined practice of pre-use inspection is the most effective means of preventing catastrophic rigging failures.

Chapter 2: The Vertical Hitch

2.1 Configuration and Mechanics: The Single Line of Force

The vertical hitch, also referred to as a straight hitch, represents the most fundamental sling configuration. Its setup is direct and uncomplicated: one end of a single sling, typically an eye, is connected to the hook of the lifting device, while the other end is attached directly to a single connection point on the load.[20]

Visually, this arrangement creates a single, straight line of force extending from the hoist hook down to the load. Imagine a large electric motor being lifted for installation. It has a single, robust lifting lug forged into the top of its housing, positioned directly over its center of gravity. A single wire rope sling with an eye at each end is used. One eye is placed on the crane hook, and the other is connected to the motor's lifting lug with a shackle. When the slack is taken up, the sling becomes a taut, vertical line. In this configuration, the sling is subjected to a tensile force that is equal to the full weight of the load.

Because the line of force is direct and uncomplicated by angles, a lift made using a vertical hitch allows the sling to be used at 100% of its rated capacity as specified on its identification tag for a vertical lift.[20] This makes it the most efficient hitch in terms of strength-to-capacity utilization. However, its simplicity in force application is mirrored by a complete lack of inherent load control, which severely restricts its application.

2.2 Applications, Limitations, and the Need for Taglines

The application of a vertical hitch is narrowly defined. It is suitable only for lifting loads that are inherently stable and have a single, designated lifting point located directly above the load's center of gravity.[23] Any deviation from this condition will cause the load to tilt as soon as it is lifted.

The primary limitation of the vertical hitch is its complete inability to control the load's orientation. A load suspended from a single point is free to rotate, and this rotation can be hazardous.[24] For wire rope slings, this twisting action can cause the strands of the rope to unwind, which permanently weakens the sling's structure. For this reason, the vertical hitch must never be used to lift long materials, loose bundles, or any load that is unbalanced or could shift during the lift.[20]

This analysis reveals the essential nature of the vertical hitch: it is an application of pure tensile strength, devoid of any stabilizing or controlling properties. The decision to use a vertical hitch is an explicit determination that the load itself is stable and requires no external control from the rigging configuration. The inherent lack of rotational control must be compensated for externally. This is accomplished through the use of a tagline—a length of rope attached to the load and held by a worker on the ground.[23] The worker uses the tagline to prevent rotation and to guide the load into its final position, acting as the external control system that the hitch itself lacks. The tagline operator must remain alert, be aware of their path of travel to avoid trips, and always stay clear of the potential fall zone should the lift fail.[2]

Chapter 3: The Choker Hitch

3.1 Configuration and Mechanics: The Cinching Principle

The choker hitch is a sling configuration designed to provide a gripping or clamping action on a load. It is formed by wrapping the sling around the circumference of the load, then passing one end of the sling (e.g., an eye or fitting) through the other, creating a noose.[20] As the lifting device raises the sling, this noose tightens, or "cinches," around the load, with the load's own weight generating the clamping force.

To visualize the configuration, imagine lifting a bundle of steel pipes. A synthetic web sling with a flat eye at each end is wrapped around the bundle. One eye is then passed through the other. The eye that has been passed through is then placed on the crane hook. As the crane begins to lift, the sling body slides through the stationary eye, tightening the loop around the pipes and securely holding them together. This cinching action is the primary function of the choker hitch, making it particularly useful for handling long, cylindrical objects or bundles of material that lack designated lifting points and would otherwise be unstable.[21]

For the hitch to function safely and correctly, several geometric rules must be followed. The point of choke—where the sling body passes through the eye and the cinching action occurs—must always be located on the body of the sling itself. It must never be positioned on an eye, a splice, a fitting, or the base of the eye where a fitting is attached.[20] Placing the choke on these components would concentrate extreme and complex stresses on a part of the sling not designed for such loading, leading to premature failure. The choker hitch must also be pulled tight before the main lift begins; it should not be allowed to jerk down and tighten during the lift, as this introduces dangerous shock loading into the system.[20]

3.2 The Critical Capacity Reduction and the Angle of Choke

The primary characteristic of the choker hitch—its ability to grip the load—is achieved at a significant cost to the sling's lifting capacity. The sharp bend and compressive forces created at the choke point generate intense localized stress within the sling material, which significantly reduces its Working Load Limit (WLL).[20] This is not a flaw but a fundamental trade-off: the rigger intentionally sacrifices a portion of the sling's raw strength to gain control over an otherwise unmanageable load. The decision to employ a choker hitch is therefore an explicit choice to prioritize load containment over maximum lifting efficiency.

The magnitude of this capacity reduction is not fixed; it is a direct function of the "angle of choke." This is the internal angle formed by the sling as it passes through the choke point. When a load is lifted and the sling is allowed to tighten naturally, this angle is typically 120 degrees or greater. At this optimal angle, the sling's capacity is reduced to approximately 75% to 80% of its rated vertical WLL.[20]

However, if the angle of choke becomes sharper (less than 120 degrees), the stresses at the choke point intensify, and the capacity reduction becomes more severe. For choke angles between 90 and 105 degrees, the capacity may be reduced to around 71% of the vertical WLL. For angles between 60 and 90 degrees, this can drop to 58%. For very sharp angles, below 60 degrees, the capacity can be reduced by 50% or more.[26] It is for this reason that an operator must never attempt to force the choke down the sling body to get a tighter grip; this action creates an unknown, dangerously sharp angle and an unquantifiable reduction in capacity, setting the stage for an unexpected failure.[25] The rigger must always account for this capacity reduction when selecting a sling for a choked lift, ensuring that the sling chosen has a vertical WLL high enough to remain safely above the load weight after the reduction factor is applied.

3.3 Variations: Single, Double, and Double-Wrap Chokers

The basic choker hitch has inherent limitations, and to address these, several variations have been developed. These are not simply alternative methods but are specific, engineered solutions designed to overcome the weaknesses of the standard configuration in particular applications.

The **single choker hitch** is the most basic form. While useful, it provides limited load control and does not achieve full 360-degree contact with the load, as the sling only contacts the load on three sides.[23] This makes it unsuitable for lifting loose bundles from which items could slip, or for loads that are difficult to balance. Its use should be restricted to short, stable, and simple loads where a basic gripping action is sufficient.[28]

The **double choker hitch** addresses the problem of lifting longer loads. This configuration uses two separate slings, each rigged as an independent choker hitch. The two hitches are spread apart along the length of the load to provide a wider base of support, which significantly improves stability and prevents the load from tipping.[24] This is the appropriate method for lifting long pipes or beams that would be unstable with a single lifting point.

The **double-wrap choker hitch** is the engineered solution to the single choker's lack of full load contact and its tendency to allow slippage on smooth surfaces. In this configuration, the sling is wrapped completely around the load two times before the eye is passed through to form the choke.[20] This double wrap provides full 360-degree contact with the load, greatly increasing the surface area and friction. This action compresses the load, prevents it from slipping out of the sling, and provides a much more secure grip, especially on smooth, cylindrical objects.[24] A rigger encountering a load that is too long for a single choker would select the double choker variation. A rigger encountering a load that is smooth and might slip out of a single choker would select the double-wrap variation. This diagnostic approach—identifying the specific problem and selecting the corresponding engineered solution—is key to advanced rigging practice.

Chapter 4: The Basket Hitch (The "U-Lift")

4.1 Configuration and Mechanics: Cradling the Load

The basket hitch is a configuration that supports a load by cradling it from underneath. This arrangement corresponds directly to the functional description of a "U-lift." The term "U-Sling" is standard terminology in the medical field for patient lifting devices, where a sling forms a U-shape to support a person.[30] In industrial rigging, the functionally identical configuration is known as a basket hitch. It is formed by passing the body of the sling under the load, then bringing both ends (eyes or fittings) up for connection to the lifting hook.[20]

Visually, the configuration resembles a basket or hammock supporting the load. Imagine lifting a large, rectangular wooden crate. A wide synthetic web sling is passed underneath the center of the crate. The two flat eyes at the ends of the sling are then brought up and placed together onto the hook of an overhead hoist. The crate now rests securely in the U-shaped "basket" formed by the sling.

This method is well-suited for lifting loads that are balanced and have a defined shape, such as crates, machinery, or welded frames.[20] A key advantage of the basket hitch is that it provides good control over the load and, unlike a single vertical hitch, prevents the load from twisting or rotating during the lift.[24] However, its effectiveness is entirely dependent on the load's stability. The basket hitch should not be used for loads that are inherently unbalanced or difficult to keep level, as the load could tip and spill from the sling.[20] The sling legs must contain the load from the sides, above its center of gravity, to maintain control.[19]

4.2 Capacity Implications: True Vertical vs. Angled Legs

The lifting capacity of a sling in a basket hitch is highly dependent on the angle of its legs. There are two primary scenarios to consider.

In the first scenario, the legs of the basket hitch are perfectly vertical, forming a 90-degree angle with the horizontal plane of the load. In this "true" basket configuration, the weight of the load is distributed perfectly and equally between the two legs of the sling. As a result, the hitch has a Working Load Limit (WLL) that is exactly twice the WLL of the same sling used in a single vertical hitch.[20] Achieving perfectly vertical legs typically requires the use of a spreader bar or lifting beam, a device that holds the two sling legs apart at a fixed distance, or the use of two separate hoist hooks.[20]

The second, more common scenario occurs when both ends of the sling are attached to a single lifting hook. In this case, the legs are not vertical but instead form an angle. The physics governing the tension in this arrangement are identical to those of a two-leg bridle hitch. As the horizontal angle of the sling legs decreases (i.e., as the legs spread farther apart), the tension on each leg increases significantly. This increased tension reduces the effective lifting capacity of the sling. A basket hitch with legs at a 60-degree angle to the horizontal will have a lower capacity than one at 90 degrees, and one at 45 degrees will have a lower capacity still.[20] This critical relationship between angle and tension must be accounted for in every lift plan.

4.3 Variations: Single, Double, and Double-Wrap Baskets

Similar to the choker hitch, the basket hitch has several variations that have been developed to handle different types of loads more effectively.

The **single basket hitch** is the standard configuration described above, where one sling cradles the load. It is the most common form of the hitch.

The **double basket hitch** is used to provide greater stability for long or wide loads. This configuration employs two separate slings, each rigged as an independent basket hitch, spread apart along the load.[20] This creates a wide, stable base of support, preventing the load from tipping end-to-end. It is critical when using this hitch that the angle between the load and the sling is 60 degrees or greater to prevent the slings from slipping inwards along the load's surface.[29]

The **double-wrap basket hitch** is an enhanced version of the single basket hitch, designed for loads that are loose, bundled, or have smooth surfaces. In this arrangement, the sling is wrapped completely around the load two times before both ends are connected to the hook.[20] This double wrap provides significantly more contact area and friction, which helps to draw loose materials (like a bundle of rebar) together and provides a much more secure grip on smooth, cylindrical objects (like a polished steel shaft) that might otherwise slide out of a single basket hitch. This variation provides excellent load control and security at the cost of requiring a longer sling.

Chapter 5: The Bridle Hitch

5.1 Configuration and Mechanics: The Multi-Leg Assembly

The bridle hitch is a sling assembly consisting of multiple, separate sling legs connected to a single master fitting at the top. This master fitting, typically a forged alloy steel master link or gathering ring, is the component that is placed on the hook of the lifting device.[9] Bridle slings are fabricated with two, three, or four legs, and each leg is attached to a separate, fixed lifting point on the load.[33]

To visualize this configuration, consider a large, heavy piece of industrial machinery that has been engineered with four dedicated lifting lugs, one at each of its top corners. To lift this machine, a four-leg wire rope bridle sling would be used. The large master link at the top of the bridle is attached to the crane hook. From this single link, four independent wire rope slings extend downwards. At the end of each sling leg is a hook, which is then connected to one of the lifting lugs on the machinery.[35] This arrangement allows for the stable and balanced lifting of loads that have multiple, designated attachment points. The legs of the bridle can be made from alloy chain, wire rope, or synthetic webbing, and can be fitted with various types of hardware to suit the load's connection points.[33]

5.2 Two-Leg Bridle: Principles of Symmetric Lifting

A two-leg bridle, also known as a double-leg bridle, is used for lifting loads that have two designated attachment points. This configuration offers significantly more stability than a single vertical hitch, preventing the load from rotating.[16] The lifting capacity of a two-leg bridle is entirely dependent on the horizontal angle formed by the sling legs. The fundamental principle of a two-leg bridle is that the load is shared equally between the two legs. However, this is only true under a precise set of conditions: the two sling legs must be of exactly equal length, the lifting hook must be positioned directly over the load's center of gravity, and the two attachment points on the load must be equidistant from that center of gravity.[20] If any of these conditions are not met, the load will be unequal, with one leg carrying a disproportionately high share of the weight, which can lead to overloading and failure.

5.3 Three- and Four-Leg Bridles: Stability vs. Load Distribution

Three-leg and four-leg bridle slings are employed when lifting loads with multiple attachment points to provide enhanced balance and stability.[16] A three-leg bridle offers a statically determinate lifting solution; if the hook is centered, the load will be distributed relatively evenly among the three legs.

A four-leg bridle, however, introduces a critical safety consideration. While it may seem intuitive that a four-leg bridle offers more lifting capacity than a three-leg bridle, this is often not the case. When lifting a rigid, unyielding load, it is practically impossible to guarantee that all four legs will be tensioned equally and share the load. Due to minute variations in leg length, attachment point height, or load rigidity, the load will almost invariably be supported by only two of the legs, typically those on a diagonal. The other two legs will serve only to balance the load and prevent it from tipping.[29]

This reality reveals the primary engineering purpose of multi-leg bridles. While they do distribute weight, their most important function is to provide stability. The choice to use a three- or four-leg bridle over a two-leg bridle is driven less by the total weight of the load and more by the load's geometry and the need to maintain a stable, level orientation throughout the lift. For this reason, safety standards and manufacturer's load charts often rate a four-leg bridle with the same Working Load Limit as a three-leg bridle of the same material and size. Riggers must calculate the capacity of a four-leg bridle as if it were a three-leg system, or in some conservative cases, as if only two legs are carrying the entire load, to ensure a safe margin against failure. The additional legs are for control, not for additive strength.

Chapter 6: The Physics of Sling Angles and Tension

6.1 Defining the Horizontal Sling Angle

In any lifting operation that uses a sling in a basket hitch or a multi-leg bridle hitch, the single most important factor determining the safety and success of the lift is the sling angle. The horizontal sling angle is defined as the angle formed between an individual sling leg and the horizontal plane of the load being lifted.[37] This angle is a direct indicator of the tension, or stress, that will be induced in the sling legs. It is a common misconception that two slings lifting a 1,000-pound load will each experience a 500-pound force. This is only true if the slings are perfectly vertical. In any other configuration, the tension will be greater than 500 pounds, and understanding this principle is paramount to preventing rigging failures.

6.2 Visualizing the Force Multiplier Effect

The increase in tension as the sling angle decreases can be understood through a simple analogy. Imagine two people carrying a heavy object between them. If they stand close together, their arms will be nearly vertical (a 90-degree angle to the horizontal). In this position, they are primarily lifting upwards, and each person supports half of the object's weight. Now, imagine they move farther apart. To continue supporting the object, their arms must angle outwards. To keep the object from falling, they must not only pull upwards to counteract gravity but also pull inwards, towards each other, to keep their arms from spreading farther apart. This inward-pulling force adds a significant horizontal component of tension to their arms. The total tension they feel is the vector sum of the vertical (lifting) force and the horizontal (inward-pulling) force. The slings in a bridle or basket hitch behave in precisely the same way.

As the horizontal sling angle becomes smaller (i.e., the legs spread wider), the horizontal component of the force grows exponentially. This phenomenon is often referred to as a "force multiplier" because the shallow angle multiplies the tension felt by the sling beyond its simple share of the load's weight.[36] A failure to account for this force multiplication is one of the most common causes of rigging accidents. A sling that is perfectly adequate to lift a load in a vertical configuration can fail catastrophically under the same load if used at too shallow an angle. This demonstrates that the geometry of the lift is as critical to safety as the weight of the load itself. The rigger is not merely lifting a weight; they are managing the forces within a geometric system.

6.3 Critical Angle Benchmarks and Tension Calculation

To ensure safety, riggers must be intimately familiar with a set of critical angle benchmarks and their corresponding tension multipliers (also called load angle factors). These multipliers allow for the calculation of the actual tension on a sling leg. The tension is found by taking the sling's share of the load and multiplying it by the factor for the given angle.

- **90 Degrees (Vertical):** When a sling leg is vertical, it forms a 90-degree angle with the horizontal. The tension multiplier is 1.0. The tension on the sling is exactly equal to its share of the load. For a 2,000-pound load on a two-leg bridle, each leg feels 1,000 pounds of tension.[37]
- **60 Degrees:** This is widely considered the ideal and preferred minimum angle for most general-purpose lifting operations.[39] At 60 degrees, the tension multiplier is approximately 1.155. For the same 2,000-pound load, the tension on each leg is not 1,000 pounds, but rather , which equals 1,155 pounds.[37] The sling must be rated for this higher tension.
- **45 Degrees:** As the angle decreases to 45 degrees, the tension increases more rapidly. The tension multiplier is 1.414. The 2,000-pound load now places , or 1,414 pounds of tension on each leg.[37] The forces on the slings are now 41% higher than their simple share of the weight.
- **30 Degrees:** This is considered the absolute minimum acceptable angle for any lift and is extremely hazardous.[42] The tension multiplier at 30 degrees is 2.0. This means the tension on each sling leg is doubled.[37] The 2,000-pound load now induces 2,000 pounds of tension on each of the two legs, for a total tension in the rigging system of 4,000 pounds. A sling rated for 1,500 pounds, which would have been safe at 60 degrees, would fail instantly at this angle. Sling angles below 30 degrees are prohibited and must never be used.[44]

These calculations make it clear that a rigger who selects a sling based only on the load's weight without considering the lift's geometry is making a critical error. If low headroom or wide attachment points result in a shallow sling angle, the rigger must revise the plan. This may involve using longer slings to increase the angle or selecting much higher-capacity slings to withstand the multiplied forces.

Conclusion: A Systematic Framework for Sling Selection

The selection of a proper sling arrangement is a systematic process rooted in the principles of mechanical engineering, material science, and regulatory compliance. It is not a matter of preference but a series of logical deductions based on a thorough analysis of the task at hand. The following five-step framework synthesizes the concepts discussed in this guide into an actionable decision-making process for ensuring a safe and efficient lift.

Step 1: Analyze the Load. The process begins with a complete characterization of the object to be lifted. The operator must determine its exact weight, locate its center of gravity, identify the number and location of any engineered lifting points, and assess its surface characteristics. Is the surface delicate and easily damaged? Are there sharp edges that could cut a sling? The answers to these questions form the foundational data for all subsequent decisions.

Step 2: Analyze the Environment. The operator must then evaluate the conditions of the worksite. This includes assessing the ambient temperature, identifying any potential exposure to chemicals or moisture, and measuring the physical constraints of the space, particularly the available headroom, which will directly impact the achievable sling angle.

Step 3: Select the Material. With a clear understanding of the load and environment, the operator can select the appropriate sling material. This choice is a conscious trade-off between durability, load protection, and ease of handling. A hot, abrasive environment may mandate an alloy chain. A fragile, finished load may require a synthetic web sling. A general-purpose lift with moderate conditions might be best served by a wire rope sling.

Step 4: Select the Hitch. Based on the load's geometry and stability, the operator must select the hitch configuration that provides the necessary degree of control. An inherently stable load with a single lifting point may allow for a vertical hitch. A long, cylindrical bundle will require the clamping force of a choker hitch, likely in a double-wrap or double-hitch variation. A balanced crate or machine will be best handled by a basket hitch. A load with multiple, fixed lifting points necessitates a bridle hitch, with the number of legs chosen to ensure stability.

Step 5: Calculate and Verify Capacity. This final step is a critical safety verification. The operator must determine the horizontal sling angle that will be formed by the chosen hitch and lifting geometry. Using the appropriate tension multiplier for that angle, the actual tension that will be applied to each sling leg must be calculated. This calculated tension must then be compared to the Working Load Limit (WLL) stated on the sling's identification tag for that specific type of hitch. The calculated tension must be less than the sling's rated WLL. If the tension exceeds the WLL, the lift plan is unsafe and must be revised. Revisions may include using longer slings to create a safer (larger) angle or selecting slings with a higher capacity. Only when the calculated forces are verified to be safely within the equipment's rated limits can the lift proceed.

Works cited

1. The Fundamentals of Rigging Safety: What Every Operator Should ..., accessed October 15, 2025, https://www.certex.com/the-fundamentals-of-rigging-safety-what-every-operator-should-know/
2. Rigging - OSHA, accessed October 15, 2025, https://www.osha.gov/sites/default/files/rigging_ships.pdf
3. When to Use What Type of Sling | Southeast Rigging, Inc., accessed October 15, 2025, https://southeastrigging.com/the-difference-between-a-wire-rope-sling-a-chain-sling-and-a-synthetic-web-sling/
4. Choosing the Best Lifting Sling: Wire Rope vs. Chain. vs. Synthetics - Mazzella Companies, accessed October 15, 2025, https://www.mazzellacompanies.com/learning-center/lifting-slings-wire-rope-slings-alloy-chain-slings-synthetic-slings/
5. Guidance on Safe Sling Use - Alloy Steel Chain Slings | Occupational Safety and Health Administration, accessed October 15, 2025, https://www.osha.gov/safe-sling-use/alloy
6. Materials Handling - Synthetic Web Slings - CCOHS, accessed October 15, 2025, https://www.ccohs.ca/oshanswers/safety_haz/materials_handling/syn_slng.html
7. Types of Industrial Lifting Slings, Advantages and Disadvantages - Holloway Houston, accessed October 15, 2025, https://www.hhilifting.com/en/news/post/industrial-lifting-slings-101-types-of-industrial-lifting-slings-advantages-and-disadvantages
8. Types of Slings for Lifting: How to Make the Smartest Buy - Duracordix, accessed October 15, 2025, https://duracordix.com/types-of-slings-for-lifting-how-to-make-the-smartest-buy/
9. 1910.184 - Slings. | Occupational Safety and Health Administration, accessed October 15, 2025, https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.184
10. 1926.251 - Rigging equipment for material handling. | Occupational Safety and Health Administration, accessed October 15, 2025, https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.251
11. ASME B30.9-2021: Slings - The ANSI Blog, accessed October 15, 2025, https://blog.ansi.org/ansi/asme-b30-9-2021-slings/
12. Updates & Revisions to the ASME B30.9 Slings Standard - Mazzella Companies, accessed October 15, 2025, https://www.mazzellacompanies.com/learning-center/asme-b30-9-2021-updates

-revisions-to-the-asme-b30-9-slings-standard/
13. Web Slings | Lift-All, accessed October 15, 2025, https://lift-all.com/product-files/catalog/web-slings.pdf
14. Guidance on Safe Sling Use - Wire Rope Slings | Occupational Safety and Health Administration, accessed October 15, 2025, https://www.osha.gov/safe-sling-use/wire
15. Guidance on Safe Sling Use - Natural and Synthetic Fiber Rope Slings - OSHA, accessed October 15, 2025, https://www.osha.gov/safe-sling-use/nat-synth-fiber
16. How to Choose the Right Number of Legs for Our Lifting Chain Sling? - Holloway Houston, accessed October 15, 2025, https://www.hhilifting.com/en/news/post/how-to-choose-the-right-number-of-legs-for-holloway-houston-chain-slings
17. Hoisting & Rigging Fundamentals, accessed October 15, 2025, https://energy.gov/sites/prod/files/2014/01/f6/HoistingRigging_Fundamentals.pdf
18. What is the ASME Standard for Webbing Sling? | liftingsling, accessed October 15, 2025, https://www.liftingsling.com/blogs/what-is-the-asme-standard-for-webbing-sling
19. WARNING - Lift-It® Manufacturing, accessed October 15, 2025, https://www.lift-it.com/pdf/Lift_It_Web_Sling_PIB.pdf
20. Which Sling Hitch Is Best for Your Lift? Vertical vs. Basket vs. Choker, accessed October 15, 2025, https://www.mazzellacompanies.com/learning-center/what-is-best-sling-hitch-vertical-basket-choker-bridle/
21. The 3 Web Sling Hitches - E-Rigging.com, accessed October 15, 2025, https://e-rigging.com/blogs/how-to/3-web-sling-hitches
22. Rigging With Slings: Basic hitches, Working Load Limits, Sling angle, Reach - F. D. Lake, accessed October 15, 2025, https://www.fdlake.com/rig-slng.html
23. Rigging - Methods of slinging hitches - ehsdb, accessed October 15, 2025, https://www.ehsdb.com/rigging---methods-of-slinging-hitches.php
24. Materials Handling – Rigging or Sling Hitches - CCOHS, accessed October 15, 2025, https://www.ccohs.ca/oshanswers/safety_haz/materials_handling/hitches.html
25. All About Rigging Slings: Sling Choker Hitch - LGH, accessed October 15, 2025, https://rentlgh.com/blog/a-thing-a-thing-a-marvelous-sling-part-2/
26. Sling Hitches | Lift-It® Manufacturing, accessed October 15, 2025, https://www.lift-it.com/info-hitches-all
27. proper Use of Choker Hitches, accessed October 15, 2025, https://www.prothermindia.com/properchokerhitch.pdf
28. Safety Focus of the Week: Rigging with a Choker Hitch (Revisited) - Engineers Construction, accessed October 15, 2025, https://www.engineersconstruction.com/2017/09/07/safety-focus-of-the-week-rigging-with-a-choker-hitch/
29. Blog Archive » Hitches and Safe Working Load (SWL) Limits - Practical Maintenance, accessed October 15, 2025,

https://practicalmaintenance.net/?p=748
30. Universal Divided Leg Lift U Sling - ProHeal-Products, accessed October 15, 2025, https://prohealproducts.com/products/universal-divided-leg-lift-u-sling
31. Universal Padded Lift U Sling - ProHeal, accessed October 15, 2025, https://prohealproducts.com/products/universal-padded-lift-u-sling
32. Patient lift sling choices: How to select for optimal safety - Medline, accessed October 15, 2025, https://www.medline.com/strategies/safe-mobility/patient-lift-sling-choices-require-safety/
33. 2-Leg, 3-Leg & 4-Leg Wire-Rope Bridles - Port City Industrial ..., accessed October 15, 2025, http://portcityindustrial.com/2-leg-3-leg-4-leg-wire-rope-bridles/
34. Wire Rope Bridles - I&I Sling, Inc. - Multi Leg Bridles, accessed October 15, 2025, https://iandisling.com/wire-rope/bridles/
35. Wire Rope Sling Bridles: 2-Leg, 3-Leg, and 4-leg Assemblies - Mazzella Companies, accessed October 15, 2025, https://www.mazzellacompanies.com/solutions/product/wire-rope-sling-bridles-2-legged-3-legged-and-4-legged/
36. How sling angles affect lifting capacity, accessed October 15, 2025, https://cdn.ymaws.com/members.iamu.org/resource/resmgr/toolbox_talks/toolbox_talk_sling_angles.pdf
37. How to Calculate Sling Angles for Safe Lifting Operations - Engineered Lifting Technologies, accessed October 15, 2025, https://www.eltlift.com/how-to-calculate-sling-angles-for-safe-lifting/
38. Calculating Sling Angles: A Guide for Safe Lifting - US Cargo Control, accessed October 15, 2025, https://www.uscargocontrol.com/blogs/blog/calculating-sling-angles
39. Calculating Sling Angles - Instruction and Examples - Ashley Sling, accessed October 15, 2025, https://ashleysling.com/calculating-sling-angles/
40. Sling Angles - Certified Slings & Supply, accessed October 15, 2025, https://www.certifiedslings.com/load-limits/sling-angles/
41. Sling Angles Best Practices - YouTube, accessed October 15, 2025, https://www.youtube.com/watch?v=fgE9OTBHFho
42. Crosby Rigging guide.pdf - Mermaids Rock, accessed October 15, 2025, https://www.mermaids-rock.com/wp-content/uploads/downloadable/Crosby%20Rigging%20guide.pdf
43. Calculating Sling Angles PDF - Scribd, accessed October 15, 2025, https://www.scribd.com/document/419412297/Calculating-Sling-Angles-pdf
44. Capacities & Hitches - Kennedy Wire Rope & Sling Co., accessed October 15, 2025, https://www.kwrs.com/wp-content/uploads/2018/04/CapacitiesandHitches.pdf