



Figure 1: Object Dependency Graph

This document describes the plan and progress of the implementation of Vulkayes.

## Synchronization

Most parameters in Vulkan require external synchronization. Synchronization is provided in two flavours: Single-thread and multi-thread. Single-thread synchronization primitives are noops, while multi-thread primitives provide actual multi-thread and multi-core synchronization. If single-thread synchronization is chosen, the Rust type system statically prevents use in multiple threads.

## Externally Synchronized Parameters

- The instance parameter in vkDestroyInstance
  - [Consequence of shared pointer usage](#)
- The device parameter in vkDestroyDevice
  - [Consequence of shared pointer usage](#)
- The queue parameter in vkQueueSubmit
  - [Synchronized internally](#)
- The fence parameter in vkQueueSubmit
  - [Synchronized internally](#)
- The queue parameter in vkQueueWaitIdle
  - [Synchronized internally](#)
- The memory parameter in vkFreeMemory
  - [Consequence of shared pointer usage](#)
- The memory parameter in vkMapMemory
  - [Synchronized internally](#)
- The memory parameter in vkUnmapMemory
  - [Synchronized internally](#)
- The buffer parameter in vkBindBufferMemory
  - [Handled by API design](#)
- The image parameter in vkBindImageMemory
  - [Handled by API design](#)

- The queue parameter in vkQueueBindSparse
- The fence parameter in vkQueueBindSparse

- The fence parameter in vkDestroyFence
  - [Consequence of shared pointer usage](#)
- The semaphore parameter in vkDestroySemaphore
  - [Consequence of shared pointer usage](#)

- The event parameter in vkDestroyEvent
- The event parameter in vkSetEvent
- The event parameter in vkResetEvent
- The queryPool parameter in vkDestroyQueryPool

- The buffer parameter in vkDestroyBuffer
  - [Consequence of shared pointer usage](#)
- The bufferView parameter in vkDestroyBufferView
  - [Consequence of shared pointer usage](#)
- The image parameter in vkDestroyImage
  - [Consequence of shared pointer usage](#)
- The imageView parameter in vkDestroyImageView
  - [Consequence of shared pointer usage](#)

- The shaderModule parameter in vkDestroyShaderModule
- The pipelineCache parameter in vkDestroyPipelineCache
- The dstCache parameter in vkMergePipelineCaches
- The pipeline parameter in vkDestroyPipeline

- The `pipelineLayout` parameter in `vkDestroyPipelineLayout`
  - [Consequence of shared pointer usage](#)
- The `sampler` parameter in `vkDestroySampler`
  - [Consequence of shared pointer usage](#)
- The `descriptorSetLayout` parameter in `vkDestroyDescriptorSetLayout`
  - [Consequence of shared pointer usage](#)
- The `descriptorPool` parameter in `vkDestroyDescriptorPool`
  - [Consequence of shared pointer usage](#)
- The `descriptorPool` parameter in `vkResetDescriptorPool`
  - [Synchronized internally](#)
- The `descriptorPool` member of the `pAllocateInfo` parameter in `vkAllocateDescriptorSets`
  - [Synchronized internally](#)
- The `descriptorPool` parameter in `vkFreeDescriptorSets`
  - [Synchronized internally](#)
- The `framebuffer` parameter in `vkDestroyFramebuffer`
  - [Consequence of shared pointer usage](#)
- The `renderPass` parameter in `vkDestroyRenderPass`
  - [Consequence of shared pointer usage](#)
- The `commandPool` parameter in `vkDestroyCommandPool`
  - [Consequence of shared pointer usage](#)
- The `commandPool` parameter in `vkResetCommandPool`
  - [Synchronized internally](#)
- The `commandPool` member of the `pAllocateInfo` parameter in `vkAllocateCommandBuffers`
  - [Synchronized internally](#)
- The `commandPool` parameter in `vkFreeCommandBuffers`
  - [Synchronized internally](#)

- The `commandBuffer` parameter in `vkBeginCommandBuffer`
- The `commandBuffer` parameter in `vkEndCommandBuffer`
- The `commandBuffer` parameter in `vkResetCommandBuffer`
- The `commandBuffer` parameter in `vkCmdBindPipeline`
- The `commandBuffer` parameter in `vkCmdSetViewport`
- The `commandBuffer` parameter in `vkCmdSetScissor`
- The `commandBuffer` parameter in `vkCmdSetLineWidth`
- The `commandBuffer` parameter in `vkCmdSetDepthBias`
- The `commandBuffer` parameter in `vkCmdSetBlendConstants`
- The `commandBuffer` parameter in `vkCmdSetDepthBounds`
- The `commandBuffer` parameter in `vkCmdSetStencilCompareMask`
- The `commandBuffer` parameter in `vkCmdSetStencilWriteMask`
- The `commandBuffer` parameter in `vkCmdSetStencilReference`
- The `commandBuffer` parameter in `vkCmdBindDescriptorSets`
- The `commandBuffer` parameter in `vkCmdBindIndexBuffer`
- The `commandBuffer` parameter in `vkCmdBindVertexBuffers`
- The `commandBuffer` parameter in `vkCmdDraw`
- The `commandBuffer` parameter in `vkCmdDrawIndexed`
- The `commandBuffer` parameter in `vkCmdDrawIndirect`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirect`
- The `commandBuffer` parameter in `vkCmdDispatch`
- The `commandBuffer` parameter in `vkCmdDispatchIndirect`
- The `commandBuffer` parameter in `vkCmdCopyBuffer`
- The `commandBuffer` parameter in `vkCmdCopyImage`
- The `commandBuffer` parameter in `vkCmdBlitImage`
- The `commandBuffer` parameter in `vkCmdCopyBufferToImage`
- The `commandBuffer` parameter in `vkCmdCopyImageToBuffer`

- The `commandBuffer` parameter in `vkCmdUpdateBuffer`
  - The `commandBuffer` parameter in `vkCmdFillBuffer`
  - The `commandBuffer` parameter in `vkCmdClearColorImage`
  - The `commandBuffer` parameter in `vkCmdClearDepthStencilImage`
  - The `commandBuffer` parameter in `vkCmdClearAttachments`
  - The `commandBuffer` parameter in `vkCmdResolveImage`
  - The `commandBuffer` parameter in `vkCmdSetEvent`
  - The `commandBuffer` parameter in `vkCmdResetEvent`
  - The `commandBuffer` parameter in `vkCmdWaitEvents`
  - The `commandBuffer` parameter in `vkCmdPipelineBarrier`
  - The `commandBuffer` parameter in `vkCmdBeginQuery`
  - The `commandBuffer` parameter in `vkCmdEndQuery`
  - The `commandBuffer` parameter in `vkCmdResetQueryPool`
  - The `commandBuffer` parameter in `vkCmdWriteTimestamp`
  - The `commandBuffer` parameter in `vkCmdCopyQueryPoolResults`
  - The `commandBuffer` parameter in `vkCmdPushConstants`
  - The `commandBuffer` parameter in `vkCmdBeginRenderPass`
  - The `commandBuffer` parameter in `vkCmdNextSubpass`
  - The `commandBuffer` parameter in `vkCmdEndRenderPass`
  - The `commandBuffer` parameter in `vkCmdExecuteCommands`
  - The `commandBuffer` parameter in `vkCmdSetDeviceMask`
  - The `commandBuffer` parameter in `vkCmdDispatchBase`
- The `commandPool` parameter in `vkTrimCommandPool`
    - Internally synchronized
- The `ycbcrConversion` parameter in `vkDestroySamplerYcbcrConversion`
  - The `descriptorUpdateTemplate` parameter in `vkDestroyDescriptorUpdateTemplate`
  - The `descriptorSet` parameter in `vkUpdateDescriptorSetWithTemplate`
  - The `commandBuffer` parameter in `vkCmdDrawIndirectCount`
  - The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCount`
  - The `commandBuffer` parameter in `vkCmdBeginRenderPass2`
  - The `commandBuffer` parameter in `vkCmdNextSubpass2`
  - The `commandBuffer` parameter in `vkCmdEndRenderPass2`
- The `surface` parameter in `vkDestroySurfaceKHR`
    - Consequence of shared pointer usage
  - The `surface` member of the `pCreateInfo` parameter in `vkCreateSwapchainKHR`
    - Handled by a combination of API design and swapchain internal synchronization
  - The `oldSwapchain` member of the `pCreateInfo` parameter in `vkCreateSwapchainKHR`
    - Internally synchronized
  - The `swapchain` parameter in `vkDestroySwapchainKHR`
    - Consequence of shared pointer usage
  - The `swapchain` parameter in `vkAcquireNextImageKHR`
    - Internally synchronized
  - The `semaphore` parameter in `vkAcquireNextImageKHR`
    - Internally synchronized
  - The `fence` parameter in `vkAcquireNextImageKHR`
    - Internally synchronized
  - The `queue` parameter in `vkQueuePresentKHR`
    - Internally synchronized
- The `surface` parameter in `vkGetDeviceGroupSurfacePresentModesKHR`
  - The `surface` parameter in `vkGetPhysicalDeviceSurfacePresentRectanglesKHR`
  - The `display` parameter in `vkCreateDisplayModeKHR`
  - The `mode` parameter in `vkGetDisplayPlaneCapabilitiesKHR`
  - The `commandBuffer` parameter in `vkCmdSetDeviceMaskKHR`
  - The `commandBuffer` parameter in `vkCmdDispatchBaseKHR`

- The `commandBuffer` parameter in `vkCmdPushDescriptorSetKHR`
- The `commandBuffer` parameter in `vkCmdPushDescriptorSetWithTemplateKHR`
- The `descriptorUpdateTemplate` parameter in `vkDestroyDescriptorUpdateTemplateKHR`
- The `descriptorSet` parameter in `vkUpdateDescriptorSetWithTemplateKHR`
- The `commandBuffer` parameter in `vkCmdBeginRenderPass2KHR`
- The `commandBuffer` parameter in `vkCmdNextSubpass2KHR`
- The `commandBuffer` parameter in `vkCmdEndRenderPass2KHR`
- The `swapchain` parameter in `vkGetSwapchainStatusKHR`
- The `ycbcrConversion` parameter in `vkDestroySamplerYcbcrConversionKHR`
- The `commandBuffer` parameter in `vkCmdDrawIndirectCountKHR`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCountKHR`
- The `callback` parameter in `vkDestroyDebugReportCallbackEXT`
- The `object` member of the `pTagInfo` parameter in `vkDebugMarkerSetObjectTagEXT`
- The `object` member of the `pNameInfo` parameter in `vkDebugMarkerSetObjectNameEXT`
- The `commandBuffer` parameter in `vkCmdBindTransformFeedbackBuffersEXT`
- The `commandBuffer` parameter in `vkCmdBeginTransformFeedbackEXT`
- The `commandBuffer` parameter in `vkCmdEndTransformFeedbackEXT`
- The `commandBuffer` parameter in `vkCmdBeginQueryIndexedEXT`
- The `commandBuffer` parameter in `vkCmdEndQueryIndexedEXT`
- The `commandBuffer` parameter in `vkCmdDrawIndirectByteCountEXT`
- The `commandBuffer` parameter in `vkCmdDrawIndirectCountAMD`
- The `commandBuffer` parameter in `vkCmdDrawIndexedIndirectCountAMD`
- The `commandBuffer` parameter in `vkCmdBeginConditionalRenderingEXT`
- The `commandBuffer` parameter in `vkCmdEndConditionalRenderingEXT`
- The `commandBuffer` parameter in `vkCmdProcessCommandsNVX`
- The `commandBuffer` parameter in `vkCmdReserveSpaceForCommandsNVX`
- The `objectTable` parameter in `vkDestroyObjectTableNVX`
- The `objectTable` parameter in `vkRegisterObjectsNVX`
- The `objectTable` parameter in `vkUnregisterObjectsNVX`
- The `commandBuffer` parameter in `vkCmdSetViewportWScalingNV`
- The `swapchain` parameter in `vkGetRefreshCycleDurationGOOGLE`
- The `swapchain` parameter in `vkGetPastPresentationTimingGOOGLE`
- The `commandBuffer` parameter in `vkCmdSetDiscardRectangleEXT`
- The `objectHandle` member of the `pNameInfo` parameter in `vkSetDebugUtilsObjectNameEXT`
- The `objectHandle` member of the `pTagInfo` parameter in `vkSetDebugUtilsObjectTagEXT`
- The `messenger` parameter in `vkDestroyDebugUtilsMessengerEXT`
- The `commandBuffer` parameter in `vkCmdSetSampleLocationsEXT`
- The `validationCache` parameter in `vkDestroyValidationCacheEXT`
- The `dstCache` parameter in `vkMergeValidationCachesEXT`
- The `commandBuffer` parameter in `vkCmdBindShadingRateImageNV`
- The `commandBuffer` parameter in `vkCmdSetViewportShadingRatePaletteNV`
- The `commandBuffer` parameter in `vkCmdSetCoarseSampleOrderNV`
- The `commandBuffer` parameter in `vkCmdWriteBufferMarkerAMD`
- The `commandBuffer` parameter in `vkCmdDrawMeshTasksNV`
- The `commandBuffer` parameter in `vkCmdDrawMeshTasksIndirectNV`
- The `commandBuffer` parameter in `vkCmdDrawMeshTasksIndirectCountNV`
- The `commandBuffer` parameter in `vkCmdSetExclusiveScissorNV`
- The `commandBuffer` parameter in `vkCmdSetLineStippleEXT`

## Validations

There are two types of validations in Vulkan API: Implicit validations, which talk about technical aspects of the API usage, and explicit validations, which talk about semantical aspects. Vulkayes aims to solve all implicit validations in the core crate. External validations are not always trivial to solve, some of them are statically

fulfilled using the type system or the API design, others are left to the user.

External validations resolved statically are enclosed in blue boxes below. Validations optionally checked at runtime are in green boxes.

## Implicit validations

### Instance

Validations for `vkCreateInstance`:

1. `pCreateInfo` must be a valid pointer to a valid `VkInstanceCreateInfo` structure
  - [Handled by API design \(ash\)](#)
2. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design \(ash\)](#)
3. `pInstance` must be a valid pointer to a `VkInstance` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkInstanceCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_INSTANCE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkDebugReportCallbackCreateInfoEXT`, `VkDebugUtilsMessengerCreateInfoEXT`, `VkValidationFeaturesEXT`, or `VkValidationFlagsEXT`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be 0
  - [Handled by API design \(ash\)](#)
5. If `pApplicationInfo` is not NULL, `pApplicationInfo` must be a valid pointer to a valid `VkApplicationInfo` structure
  - [Handled by API design \(ash\)](#)
6. If `enabledLayerCount` is not 0, `ppEnabledLayerNames` must be a valid pointer to an array of `enabledLayerCount` null-terminated UTF-8 strings
  - [Returns error](#)
7. If `enabledExtensionCount` is not 0, `ppEnabledExtensionNames` must be a valid pointer to an array of `enabledExtensionCount` null-terminated UTF-8 strings
  - [Returns error](#)

### Device

Validations for `vkCreateDevice`:

1. `physicalDevice` must be a valid `VkPhysicalDevice` handle
  - [Handled by API design \(ash\)](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkDeviceCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design \(ash\)](#)
4. `pDevice` must be a valid pointer to a `VkDevice` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkDeviceCreateInfo`:

1. sType must be VK\_STRUCTURE\_TYPE\_DEVICE\_CREATE\_INFO
  - [Handled by API design \(ash\)](#)
2. Each pNext member of any structure (including this one) in the pNext chain must be either NULL or a pointer to a valid instance of VkDeviceDiagnosticsConfigCreateInfoNV, VkDeviceGroupDeviceCreateInfo, VkDeviceMemoryOverallocationCreateInfoAMD, VkPhysicalDevice16BitStorageFeatures, VkPhysicalDevice8BitStorageFeatures, VkPhysicalDeviceASTCDecodeFeaturesEXT, VkPhysicalDeviceBlendOperationAdvancedFeaturesEXT, VkPhysicalDeviceBufferDeviceAddressFeatures, VkPhysicalDeviceBufferDeviceAddressFeaturesEXT, VkPhysicalDeviceCoherentMemoryFeaturesAMD, VkPhysicalDeviceComputeShaderDerivativesFeaturesNV, VkPhysicalDeviceConditionalRenderingFeaturesEXT, VkPhysicalDeviceCooperativeMatrixFeaturesNV, VkPhysicalDeviceCornerSampledImageFeaturesNV, VkPhysicalDeviceCoverageReductionModeFeaturesNV, VkPhysicalDeviceDedicatedAllocationImageAliasingFeaturesNV, VkPhysicalDeviceDepthClipEnableFeaturesEXT, VkPhysicalDeviceDescriptorIndexingFeatures, VkPhysicalDeviceDeviceGeneratedCommandsFeaturesNV, VkPhysicalDeviceDiagnosticsConfigFeaturesNV, VkPhysicalDeviceExclusiveScissorFeaturesNV, VkPhysicalDeviceFeatures2, VkPhysicalDeviceFragmentDensityMapFeaturesEXT, VkPhysicalDeviceFragmentShaderBarycentricFeaturesNV, VkPhysicalDeviceFragmentShaderInterlockFeaturesEXT, VkPhysicalDeviceHostQueryResetFeatures, VkPhysicalDeviceImagelessFramebufferFeatures, VkPhysicalDeviceIndexTypeUint8FeaturesEXT, VkPhysicalDeviceInlineUniformBlockFeaturesEXT, VkPhysicalDeviceLineRasterizationFeaturesEXT, VkPhysicalDeviceMemoryPriorityFeaturesEXT, VkPhysicalDeviceMeshShaderFeaturesNV, VkPhysicalDeviceMultiviewFeatures, VkPhysicalDevicePerformanceQueryFeaturesKHR, VkPhysicalDevicePipelineCreationCacheControlFeaturesEXT, VkPhysicalDevicePipelineExecutablePropertiesFeaturesKHR, VkPhysicalDeviceProtectedMemoryFeatures, VkPhysicalDeviceRayTracingFeaturesKHR, VkPhysicalDeviceRepresentativeFragmentTestFeaturesNV, VkPhysicalDeviceSamplerYcbcrConversionFeatures, VkPhysicalDeviceScalarBlockLayoutFeatures, VkPhysicalDeviceSeparateDepthStencilLayoutsFeatures, VkPhysicalDeviceShaderAtomicInt64Features, VkPhysicalDeviceShaderClockFeaturesKHR, VkPhysicalDeviceShaderDemoteToHelperInvocationFeaturesEXT, VkPhysicalDeviceShaderDrawParametersFeatures, VkPhysicalDeviceShaderFloat16Int8Features, VkPhysicalDeviceShaderImageFootprintFeaturesNV, VkPhysicalDeviceShaderIntegerFunctions2FeaturesINTEL, VkPhysicalDeviceShaderSMBuiltinsFeaturesNV, VkPhysicalDeviceShaderSubgroupExtendedTypesFeatures, VkPhysicalDeviceShadingRateImageFeaturesNV, VkPhysicalDeviceSubgroupSizeControlFeaturesEXT, VkPhysicalDeviceTexelBufferAlignmentFeaturesEXT, VkPhysicalDeviceTextureCompressionASTCHDRFeaturesEXT, VkPhysicalDeviceTimelineSemaphoreFeatures, VkPhysicalDeviceTransformFeedbackFeaturesEXT, VkPhysicalDeviceUniformBufferStandardLayoutFeatures, VkPhysicalDeviceVariablePointersFeatures, VkPhysicalDeviceVertexAttributeDivisorFeaturesEXT, VkPhysicalDeviceVulkan11Features, VkPhysicalDeviceVulkan12Features, VkPhysicalDeviceVulkanMemoryModelFeatures, or VkPhysicalDeviceYcbcrImageArraysFeaturesEXT
  - [Handled by API design \(ash\)](#)
3. The sType value of each struct in the pNext chain must be unique
  - [Handled by API design](#)
4. flags must be 0
  - [Handled by API design \(ash\)](#)
5. pQueueCreateInfos must be a valid pointer to an array of queueCreateInfoCount valid VkDeviceQueueCreateInfo structures
  - [Handled by API design \(ash\)](#)



6. If `enabledLayerCount` is not 0, `ppEnabledLayerNames` must be a valid pointer to an array of `enabledLayerCount` null-terminated UTF-8 strings
  - Returns error
7. If `enabledExtensionCount` is not 0, `ppEnabledExtensionNames` must be a valid pointer to an array of `enabledExtensionCount` null-terminated UTF-8 strings
  - Returns error
8. If `pEnabledFeatures` is not NULL, `pEnabledFeatures` must be a valid pointer to a valid `VkPhysicalDeviceFeatures` structure
  - Handled by API design (ash)
9. `queueCreateInfoCount` must be greater than 0
  - Returns error

## Queue

Validations for `VkDeviceQueueCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_DEVICE_QUEUE_CREATE_INFO`
  - Handled by API design (ash)
2. `pNext` must be NULL or a pointer to a valid instance of `VkDeviceQueueGlobalPriorityCreateInfoEXT`
  - Handled by API design (ash)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - Handled by API design
4. `flags` must be a valid combination of `VkDeviceQueueCreateFlagBits` values
  - Handled by API design (ash)
5. `pQueuePriorities` must be a valid pointer to an array of `queueCount` float values
  - Handled by API design (ash)
6. `queueCount` must be greater than 0
  - Returns error

Validations for `vkGetDeviceQueue`:

1. `device` must be a valid `VkDevice` handle
  - Handled by API design
2. `pQueue` must be a valid pointer to a `VkQueue` handle
  - Handled by API design

Validations for `vkGetDeviceQueue2`:

1. `device` must be a valid `VkDevice` handle
  - Handled by API design
2. `pQueueInfo` must be a valid pointer to a valid `VkDeviceQueueInfo2` structure
  - Handled by API design
3. `pQueue` must be a valid pointer to a `VkQueue` handle
  - Handled by API design

Validations for `VkDeviceQueueInfo2`:

1. sType must be VK\_STRUCTURE\_TYPE\_DEVICE\_QUEUE\_INFO\_2
  - [Handled by API design \(ash\)](#)
2. pNext must be NULL
  - [Handled by API design \(ash\)](#)
3. flags must be a valid combination of VkDeviceQueueCreateFlagBits values
  - [Handled by API design \(ash\)](#)

Validations for vkQueueSubmit:

1. queue must be a valid VkQueue handle
  - [Handled by API design](#)
2. If submitCount is not 0, pSubmits must be a valid pointer to an array of submitCount valid VkSubmitInfo structures
  - [Handled by API design](#)
3. If fence is not VK\_NULL\_HANDLE, fence must be a valid VkFence handle
  - [Handled by API design](#)
4. Both of fence, and queue that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same VkDevice
  - [Returns error](#)

Validations for VkSubmitInfo:

1. sType must be VK\_STRUCTURE\_TYPE\_SUBMIT\_INFO
  - [Handled by API design \(ash\)](#)
2. Each pNext member of any structure (including this one) in the pNext chain must be either NULL or a pointer to a valid instance of VkD3D12FenceSubmitInfoKHR, VkDeviceGroupSubmitInfo, VkPerformanceQuerySubmitInfoKHR, VkProtectedSubmitInfo, VkTimelineSemaphoreSubmitInfo, VkWin32KeyedMutexAcquireReleaseInfoKHR, or VkWin32KeyedMutexAcquireReleaseInfoNV
  - [Handled by API design \(ash\)](#)
3. The sType value of each struct in the pNext chain must be unique
  - [Handled by API design](#)
4. If waitSemaphoreCount is not 0, pWaitSemaphores must be a valid pointer to an array of waitSemaphoreCount valid VkSemaphore handles
  - [Handled by API design \(ash\)](#)
5. If waitSemaphoreCount is not 0, pWaitDstStageMask must be a valid pointer to an array of waitSemaphoreCount valid combinations of VkPipelineStageFlagBits values
  - [Handled by API design \(ash\)](#)
6. Each element of pWaitDstStageMask must not be 0
  - [Handled by API design](#)
7. If commandBufferCount is not 0, pCommandBuffers must be a valid pointer to an array of commandBufferCount valid VkCommandBuffer handles
  - [Handled by API design \(ash\)](#)
8. If signalSemaphoreCount is not 0, pSignalSemaphores must be a valid pointer to an array of signalSemaphoreCount valid VkSemaphore handles
  - [Handled by API design \(ash\)](#)
9. Each of the elements of pCommandBuffers, the elements of pSignalSemaphores, and the elements of pWaitSemaphores that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same VkDevice
  - [Returns error](#)

## Swapchain

Validations for `vkCreateSwapchainKHR`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design \(ash\)](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkSwapchainCreateInfoKHR` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design \(ash\)](#)
4. `pSwapchain` must be a valid pointer to a `VkSwapchainKHR` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkSwapchainCreateInfoKHR`:

1. `sType` must be `VK_STRUCTURE_TYPE_SWAPCHAIN_CREATE_INFO_KHR`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkDeviceGroupSwapchainCreateInfoKHR`, `VkImageFormatListCreateInfo`, `VkSurfaceFullScreenExclusiveInfoEXT`, `VkSurfaceFullScreenExclusiveWin32InfoEXT`, `VkSwapchainCounterCreateInfoEXT`, or `VkSwapchainDisplayNativeHdrCreateInfoAMD`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkSwapchainCreateFlagBitsKHR` values
  - [Handled by API design \(ash\)](#)
5. `surface` must be a valid `VkSurfaceKHR` handle
  - [Handled by API design \(ash\)](#)
6. `imageFormat` must be a valid `VkFormat` value
  - [Handled by API design \(ash\)](#)
7. `imageColorSpace` must be a valid `VkColorSpaceKHR` value
  - [Handled by API design \(ash\)](#)
8. `imageUsage` must be a valid combination of `VkImageUsageFlagBits` values
  - [Handled by API design \(ash\)](#)
9. `imageUsage` must not be 0
  - [Returns error](#)

10. `imageSharingMode` must be a valid `VkSharingMode` value
  - [Handled by API design \(ash\)](#)
11. `preTransform` must be a valid `VkSurfaceTransformFlagBitsKHR` value
  - [Handled by API design \(ash\)](#)
12. `compositeAlpha` must be a valid `VkCompositeAlphaFlagBitsKHR` value
  - [Handled by API design \(ash\)](#)
13. `presentMode` must be a valid `VkPresentModeKHR` value
  - [Handled by API design \(ash\)](#)
14. If `oldSwapchain` is not `VK_NULL_HANDLE`, `oldSwapchain` must be a valid `VkSwapchainKHR` handle
  - [Handled by API design \(ash\)](#)
15. If `oldSwapchain` is a valid handle, it must have been created, allocated, or retrieved from `surface`
  - [Handled by API design](#)
16. Both of `oldSwapchain`, and `surface` that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same `VkInstance`
  - [Handled by API design](#)

Validations for `vkGetSwapchainImagesKHR`:

1. `device` must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `swapchain` must be a valid `VkSwapchainKHR` handle
  - [Handled by API design](#)
3. `pSwapchainImageCount` must be a valid pointer to a `uint32_t` value
  - [Handled by API design \(ash\)](#)
4. If the value referenced by `pSwapchainImageCount` is not 0, and `pSwapchainImages` is not NULL, `pSwapchainImages` must be a valid pointer to an array of `pSwapchainImageCount` `VkImage` handles
  - [Handled by API design \(ash\)](#)
5. Both of `device`, and `swapchain` must have been created, allocated, or retrieved from the same `VkInstance`
  - [Handled by API design](#)

Validations for `vkQueuePresentKHR`:

1. `queue` must be a valid `VkQueue` handle
  - [Handled by API design \(ash\)](#)
2. `pPresentInfo` must be a valid pointer to a valid `VkPresentInfoKHR` structure
  - [Handled by API design \(ash\)](#)

Validations for `VkPresentInfoKHR`:

1. sType must be VK\_STRUCTURE\_TYPE\_PRESENT\_INFO\_KHR
  - [Handled by API design \(ash\)](#)
2. Each pNext member of any structure (including this one) in the pNext chain must be either NULL or a pointer to a valid instance of VkDeviceGroupPresentInfoKHR, VkDisplayPresentInfoKHR, VkPresentFrameTokenGGP, VkPresentRegionsKHR, or VkPresentTimesInfoGOOGLE
  - [Handled by API design \(ash\)](#)
3. The sType value of each struct in the pNext chain must be unique
  - [Handled by API design](#)
4. If waitSemaphoreCount is not 0, pWaitSemaphores must be a valid pointer to an array of waitSemaphoreCount valid VkSemaphore handles
  - [Handled by API design \(ash\)](#)
5. pSwapchains must be a valid pointer to an array of swapchainCount valid VkSwapchainKHR handles
  - [Handled by API design \(ash\)](#)
6. pImageIndices must be a valid pointer to an array of swapchainCount uint32\_t values
  - [Handled by API design \(ash\)](#)
7. If pResults is not NULL, pResults must be a valid pointer to an array of swapchainCount VkResult values
  - [Handled by API design \(ash\)](#)
8. swapchainCount must be greater than 0
  - [Returns error](#)
9. Both of the elements of pSwapchains, and the elements of pWaitSemaphores that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same VkInstance
  - [Returns error](#)

Validations for vkAcquireNextImageKHR:

1. device must be a valid VkDevice handle
  - [Handled by API design](#)
2. swapchain must be a valid VkSwapchainKHR handle
  - [Handled by API design](#)
3. If semaphore is not VK\_NULL\_HANDLE, semaphore must be a valid VkSemaphore handle
  - [Handled by API design](#)
4. If fence is not VK\_NULL\_HANDLE, fence must be a valid VkFence handle
  - [Handled by API design](#)
5. pImageIndex must be a valid pointer to a uint32\_t value
  - [Handled by API design \(ash\)](#)
6. If semaphore is a valid handle, it must have been created, allocated, or retrieved from device
  - [Returns error](#)
7. If fence is a valid handle, it must have been created, allocated, or retrieved from device
  - [Returns error](#)
8. Both of device, and swapchain that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same VkInstance
  - [Handled by API design](#)

## Command Buffer

Validations for vkCreateCommandPool:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkCommandPoolCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pCommandPool` must be a valid pointer to a `VkCommandPool` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkCommandPoolCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_COMMAND_POOL_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL
  - [Handled by API design \(ash\)](#)
3. `flags` must be a valid combination of `VkCommandPoolCreateFlagBits` values
  - [Handled by API design \(ash\)](#)

Validations for `vkTrimCommandPool`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `commandPool` must be a valid `VkCommandPool` handle
  - [Handled by API design](#)
3. `flags` must be 0
  - [Handled by API design](#)
4. `commandPool` must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

Validations for `vkResetCommandPool`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `commandPool` must be a valid `VkCommandPool` handle
  - [Handled by API design](#)
3. `flags` must be a valid combination of `VkCommandPoolResetFlagBits` values
  - [Handled by API design](#)
4. `commandPool` must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

Validations for `VkCommandBufferAllocateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_COMMAND_BUFFER_ALLOCATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL
  - [Handled by API design \(ash\)](#)
3. `commandPool` must be a valid `VkCommandPool` handle
  - [Handled by API design \(ash\)](#)
4. `level` must be a valid `VkCommandBufferLevel` value
  - [Handled by API design \(ash\)](#)

## Fence

Validations for `vkCreateFence`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design \(ash\)](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkFenceCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design \(ash\)](#)
4. `pFence` must be a valid pointer to a `VkFence` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkFenceCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_FENCE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkExportFenceCreateInfo` or `VkExportFenceWin32HandleInfoKHR`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkFenceCreateFlagBits` values
  - [Handled by API design \(ash\)](#)

Validations for `vkGetFenceStatus`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. fence must be a valid `VkFence` handle
  - [Handled by API design](#)
3. fence must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

Validations for `vkResetFences`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pFences` must be a valid pointer to an array of `fenceCount` valid `VkFence` handles
  - [Handled by API design](#)
3. `fenceCount` must be greater than 0
  - [Handled by API design](#)
4. Each element of `pFences` must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

Validations for `vkWaitForFences`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pFences` must be a valid pointer to an array of `fenceCount` valid `VkFence` handles
  - [Handled by API design](#)
3. `fenceCount` must be greater than 0
  - [Handled by API design](#)
4. Each element of `pFences` must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

## Semaphore

Validations for `vkCreateSemaphore`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design \(ash\)](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkSemaphoreCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design \(ash\)](#)
4. `pSemaphore` must be a valid pointer to a `VkSemaphore` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkSemaphoreCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_SEMAPHORE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkExportSemaphoreCreateInfo`, `VkExportSemaphoreWin32HandleInfoKHR`, or `VkSemaphoreTypeCreateInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be 0
  - [Handled by API design \(ash\)](#)

Validations for `VkSemaphoreTypeCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_SEMAPHORE_TYPE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `semaphoreType` must be a valid `VkSemaphoreType` value
  - [Handled by API design \(ash\)](#)

## Image

Validations for `vkCreateImage`:



1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkImageCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pImage` must be a valid pointer to a `VkImage` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkImageCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_IMAGE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkDedicatedAllocationImageCreateInfoNV`, `VkExternalFormatANDROID`, `VkExternalMemoryImageCreateInfo`, `VkExternalMemoryImageCreateInfoNV`, `VkImageDrmFormatModifierExplicitCreateInfoEXT`, `VkImageDrmFormatModifierListCreateInfoEXT`, `VkImageFormatListCreateInfo`, `VkImageStencilUsageCreateInfo`, or `VkImageSwapchainCreateInfoKHR`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkImageCreateFlagBits` values
  - [Handled by API design](#)
5. `imageType` must be a valid `VkImageType` value
  - [Handled by API design \(ash\)](#)
6. `format` must be a valid `VkFormat` value
  - [Handled by API design \(ash\)](#)
7. `samples` must be a valid `VkSampleCountFlagBits` value
  - [Handled by API design \(ash\)](#)
8. `tiling` must be a valid `VkImageTiling` value
  - [Handled by API design \(ash\)](#)
9. `usage` must be a valid combination of `VkImageUsageFlagBits` values
  - [Handled by API design](#)
10. `usage` must not be 0
  - [Returns error](#)
11. `sharingMode` must be a valid `VkSharingMode` value
  - [Handled by API design \(ash\)](#)
12. `initialLayout` must be a valid `VkImageLayout` value
  - [Handled by API design \(ash\)](#)

Validations for `vkBindImageMemory`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. image must be a valid `VkImage` handle
  - [Handled by API design](#)
3. memory must be a valid `VkDeviceMemory` handle
  - [Handled by API design](#)
4. image must have been created, allocated, or retrieved from device
  - [Handled by API design](#)
5. memory must have been created, allocated, or retrieved from device
  - [Returns error](#)

Validations for `vkCreateImageView`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkImageViewCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pView` must be a valid pointer to a `VkImageView` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkImageViewCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_IMAGE_VIEW_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkImageViewASTCDecodeModeEXT`, `VkImageViewUsageCreateInfo`, or `VkSamplerYcbcrConversionInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkImageViewCreateFlagBits` values
  - [Handled by API design](#)
5. image must be a valid `VkImage` handle
  - [Handled by API design](#)
6. `viewType` must be a valid `VkImageViewType` value
  - [Handled by API design](#)
7. `format` must be a valid `VkFormat` value
  - [Handled by API design](#)
8. `components` must be a valid `VkComponentMapping` structure
  - [Handled by API design](#)
9. `subresourceRange` must be a valid `VkImageSubresourceRange` structure
  - [Handled by API design](#)

## Buffer

Validations for `vkCreateBuffer`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkBufferCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pBuffer` must be a valid pointer to a `VkBuffer` handle
  - [Handled by API design \(ash\)](#)

#### Validations for `VkBufferCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_BUFFER_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkBufferDeviceAddressCreateInfoEXT`, `VkBufferOpaqueCaptureAddressCreateInfo`, `VkDedicatedAllocationBufferCreateInfoNV`, or `VkExternalMemoryBufferCreateInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkBufferCreateFlagBits` values
  - [Handled by API design](#)
5. `usage` must be a valid combination of `VkBufferUsageFlagBits` values
  - [Handled by API design](#)
6. `usage` must not be 0
  - [Return error](#)
7. `sharingMode` must be a valid `VkSharingMode` value
  - [Handled by API design](#)

#### Validations for `vkBindBufferMemory`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. buffer must be a valid `VkBuffer` handle
  - [Handled by API design](#)
3. memory must be a valid `VkDeviceMemory` handle
  - [Handled by API design](#)
4. buffer must have been created, allocated, or retrieved from device
  - [Handled by API design](#)
5. memory must have been created, allocated, or retrieved from device
  - [Returns error](#)

#### Validations for `vkCreateBufferView`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkBufferViewCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pView` must be a valid pointer to a `VkBufferView` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkBufferViewCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_BUFFER_VIEW_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL
  - [Handled by API design \(ash\)](#)
3. `flags` must be 0
  - [Handled by API design](#)
4. `buffer` must be a valid `VkBuffer` handle
  - [Handled by API design \(ash\)](#)
5. `format` must be a valid `VkFormat` value
  - [Handled by API design \(ash\)](#)

## Memory

Validations for `vkMapMemory`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `memory` must be a valid `VkDeviceMemory` handle
  - [Handled by API design](#)
3. `flags` must be 0
  - [Handled by API design](#)
4. `ppData` must be a valid pointer to a pointer value
  - [Handled by API design \(ash\)](#)
5. `memory` must have been created, allocated, or retrieved from device
  - [Handled by API design](#)

Validations for `vkFlushMappedMemoryRanges`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pMemoryRanges` must be a valid pointer to an array of `memoryRangeCount` valid `VkMappedMemoryRange` structures
  - [Handled by API design](#)
3. `memoryRangeCount` must be greater than 0
  - [Handled by API design](#)

Validations for `vkInvalidateMappedMemoryRanges`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pMemoryRanges` must be a valid pointer to an array of `memoryRangeCount` valid `VkMappedMemoryRange` structures
  - [Handled by API design](#)
3. `memoryRangeCount` must be greater than 0
  - [Handled by API design](#)

Validations for `VkMappedMemoryRange`:

1. `sType` must be `VK_STRUCTURE_TYPE_MAPPED_MEMORY_RANGE`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL
  - [Handled by API design \(ash\)](#)
3. `memory` must be a valid `VkDeviceMemory` handle
  - [Handled by API design](#)

## Descriptors

Validations for `vkCreateDescriptorSetLayout`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkDescriptorSetLayoutCreateInfo` structure
  - [Handled by API design](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pSetLayout` must be a valid pointer to a `VkDescriptorSetLayout` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkDescriptorSetLayoutCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_DESCRIPTOR_SET_LAYOUT_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL or a pointer to a valid instance of `VkDescriptorSetLayoutBindingFlagsCreateInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkDescriptorSetLayoutCreateFlagBits` values
  - [Handled by API design](#)
5. If `bindingCount` is not 0, `pBindings` must be a valid pointer to an array of `bindingCount` valid `VkDescriptorSetLayoutBinding` structures
  - [Handled by API design](#)

Validations for `VkDescriptorSetLayoutBinding`:

1. descriptorType must be a valid VkDescriptorType value
  - [Handled by API design](#)

Validations for vkCreateDescriptorPool:

1. device must be a valid VkDevice handle
  - [Handled by API design](#)
2. pCreateInfo must be a valid pointer to a valid VkDescriptorPoolCreateInfo structure
  - [Handled by API design \(ash\)](#)
3. If pAllocator is not NULL, pAllocator must be a valid pointer to a valid VkAllocationCallbacks structure
  - [Handled by API design](#)
4. pDescriptorPool must be a valid pointer to a VkDescriptorPool handle
  - [Handled by API design \(ash\)](#)

Validations for VkDescriptorPoolCreateInfo:

1. sType must be VK\_STRUCTURE\_TYPE\_DESCRIPTOR\_POOL\_CREATE\_INFO
  - [Handled by API design \(ash\)](#)
2. pNext must be NULL or a pointer to a valid instance of VkDescriptorPoolInlineUniformBlockCreateInfoEXT
  - [Handled by API design \(ash\)](#)
3. The sType value of each struct in the pNext chain must be unique
  - [Handled by API design](#)
4. flags must be a valid combination of VkDescriptorPoolCreateFlagBits values
  - [Handled by API design \(ash\)](#)
5. pPoolSizes must be a valid pointer to an array of poolSizeCount valid VkDescriptorPoolSize structures
  - [Handled by API design \(ash\)](#)
6. poolSizeCount must be greater than 0
  - [Guaranteed by the type system](#)

Validations for VkDescriptorPoolInlineUniformBlockCreateInfoEXT:

1. sType must be VK\_STRUCTURE\_TYPE\_DESCRIPTOR\_POOL\_INLINE\_UNIFORM\_BLOCK\_CREATE\_INFO\_EXT
  - [Handled by API design \(ash\)](#)

Validations for vkAllocateDescriptorSets:

1. device must be a valid VkDevice handle
  - [Handled by API design](#)
2. pAllocateInfo must be a valid pointer to a valid VkDescriptorSetAllocateInfo structure
  - [Handled by API design](#)
3. pDescriptorSets must be a valid pointer to an array of pAllocateInfo::descriptorSetCount VkDescriptorSet handles
  - [Handled by API design \(ash\)](#)
4. The value referenced by pAllocateInfo::descriptorSetCount must be greater than 0
  - [Guaranteed by the type system](#)

Validations for VkDescriptorSetAllocateInfo:

1. `sType` must be `VK_STRUCTURE_TYPE_DESCRIPTOR_SET_ALLOCATE_INFO`
    - [Handled by API design \(ash\)](#)
  2. `pNext` must be `NULL` or a pointer to a valid instance of `VkDescriptorSetVariableDescriptorCountAllocateInfo`
    - [Handled by API design \(ash\)](#)
  3. The `sType` value of each struct in the `pNext` chain must be unique
    - [Handled by API design](#)
  4. `descriptorPool` must be a valid `VkDescriptorPool` handle
    - [Handled by API design](#)
  5. `pSetLayouts` must be a valid pointer to an array of `descriptorSetCount` valid `VkDescriptorSetLayout` handles
    - [Handled by API design](#)
6. `descriptorSetCount` must be greater than 0
    - [Returns error](#)
  7. Both of `descriptorPool`, and the elements of `pSetLayouts` must have been created, allocated, or retrieved from the same `VkDevice`
    - [Returns error](#)

Validations for `vkCreateSampler`:

1. `device` must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkSamplerCreateInfo` structure
  - [Handled by API design](#)
3. If `pAllocator` is not `NULL`, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pSampler` must be a valid pointer to a `VkSampler` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkSamplerCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_SAMPLER_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either `NULL` or a pointer to a valid instance of `VkSamplerReductionModeCreateInfo` or `VkSamplerYcbcrConversionInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkSamplerCreateFlagBits` values
  - [Handled by API design](#)
5. `magFilter` must be a valid `VkFilter` value
  - [Handled by API design](#)
6. `minFilter` must be a valid `VkFilter` value
  - [Handled by API design](#)
7. `mipmapMode` must be a valid `VkSamplerMipmapMode` value
  - [Handled by API design](#)
8. `addressModeU` must be a valid `VkSamplerAddressMode` value
  - [Handled by API design](#)
9. `addressModeV` must be a valid `VkSamplerAddressMode` value
  - [Handled by API design](#)
10. `addressModeW` must be a valid `VkSamplerAddressMode` value
  - [Handled by API design](#)

Validations for `VkDescriptorBufferInfo`:

1. `buffer` must be a valid `VkBuffer` handle
  - [Handled by API design](#)

Validations for `VkDescriptorImageInfo`:

1. Both of `imageView`, and `sampler` that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same `VkDevice`
  - [Returns error](#)

Validations for `VkWriteDescriptorSetInlineUniformBlockEXT`:

1. `sType` must be `VK_STRUCTURE_TYPE_WRITE_DESCRIPTOR_SET_INLINE_UNIFORM_BLOCK_EXT`
  - [Handled by API design \(ash\)](#)
2. `pData` must be a valid pointer to an array of `dataSize` bytes
  - [Handled by API design](#)
3. `dataSize` must be greater than 0
  - [Returns error](#)

Validations for `VkWriteDescriptorSet`:



1. sType must be VK\_STRUCTURE\_TYPE\_WRITE\_DESCRIPTOR\_SET
    - [Handled by API design \(ash\)](#)
  2. Each pNext member of any structure (including this one) in the pNext chain must be either NULL or a pointer to a valid instance of VkWriteDescriptorSetAccelerationStructureKHR or VkWriteDescriptorSetInlineUniformBlockEXT
    - [Handled by API design \(ash\)](#)
  3. The sType value of each struct in the pNext chain must be unique
    - [Handled by API design](#)
  4. descriptorType must be a valid VkDescriptorType value
    - [Handled by API design](#)
5. descriptorCount must be greater than 0
    - [Returns error](#)
6. Both of dstSet, and the elements of pTexelBufferView that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same VkDevice

Validations for VkCopyDescriptorSet:

1. sType must be VK\_STRUCTURE\_TYPE\_COPY\_DESCRIPTOR\_SET
    - [Handled by API design \(ash\)](#)
  2. pNext must be NULL
    - [Handled by API design \(ash\)](#)
  3. srcSet must be a valid VkDescriptorSet handle
    - [Handled by API design](#)
  4. dstSet must be a valid VkDescriptorSet handle
    - [Handled by API design](#)
5. Both of dstSet, and srcSet must have been created, allocated, or retrieved from the same VkDevice

Validations for vkUpdateDescriptorSets:

1. device must be a valid VkDevice handle
  - [Handled by API design](#)
2. If descriptorWriteCount is not 0, pDescriptorWrites must be a valid pointer to an array of descriptorWriteCount valid VkWriteDescriptorSet structures
  - [Handled by API design](#)
3. If descriptorCopyCount is not 0, pDescriptorCopies must be a valid pointer to an array of descriptorCopyCount valid VkCopyDescriptorSet structures
  - [Handled by API design](#)

## Render pass

Validations for vkCreateRenderPass:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkRenderPassCreateInfo` structure
  - [Handled by API design](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pRenderPass` must be a valid pointer to a `VkRenderPass` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkRenderPassCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_RENDER_PASS_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. Each `pNext` member of any structure (including this one) in the `pNext` chain must be either NULL or a pointer to a valid instance of `VkRenderPassFragmentDensityMapCreateInfoEXT`, `VkRenderPassInputAttachmentAspectCreateInfo`, or `VkRenderPassMultiviewCreateInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkRenderPassCreateFlagBits` values
  - [Handled by API design](#)
5. If `attachmentCount` is not 0, `pAttachments` must be a valid pointer to an array of `attachmentCount` valid `VkAttachmentDescription` structures
  - [Handled by API design](#)
6. `pSubpasses` must be a valid pointer to an array of `subpassCount` valid `VkSubpassDescription` structures
  - [Handled by API design](#)
7. If `dependencyCount` is not 0, `pDependencies` must be a valid pointer to an array of `dependencyCount` valid `VkSubpassDependency` structures
  - [Handled by API design](#)
8. `subpassCount` must be greater than 0
  - [Returns error](#)

Validations for `VkAttachmentDescription`:

1. flags must be a valid combination of `VkAttachmentDescriptionFlagBits` values
  - [Handled by API design](#)
2. format must be a valid `VkFormat` value
  - [Handled by API design \(ash\)](#)
3. samples must be a valid `VkSampleCountFlagBits` value
  - [Handled by API design \(ash\)](#)
4. loadOp must be a valid `VkAttachmentLoadOp` value
  - [Handled by API design \(ash\)](#)
5. storeOp must be a valid `VkAttachmentStoreOp` value
  - [Handled by API design \(ash\)](#)
6. stencilLoadOp must be a valid `VkAttachmentLoadOp` value
  - [Handled by API design \(ash\)](#)
7. stencilStoreOp must be a valid `VkAttachmentStoreOp` value
  - [Handled by API design \(ash\)](#)
8. initialLayout must be a valid `VkImageLayout` value
  - [Handled by API design \(ash\)](#)
9. finalLayout must be a valid `VkImageLayout` value
  - [Handled by API design](#)

#### Validations for `VkSubpassDescription`:

1. flags must be a valid combination of `VkSubpassDescriptionFlagBits` values
  - [Handled by API design](#)
2. pipelineBindPoint must be a valid `VkPipelineBindPoint` value
  - [Handled by API design \(ash\)](#)
3. If `inputAttachmentCount` is not 0, `pInputAttachments` must be a valid pointer to an array of `inputAttachmentCount` valid `VkAttachmentReference` structures
  - [Handled by API design](#)
4. If `colorAttachmentCount` is not 0, `pColorAttachments` must be a valid pointer to an array of `colorAttachmentCount` valid `VkAttachmentReference` structures
  - [Handled by API design](#)
5. If `colorAttachmentCount` is not 0, and `pResolveAttachments` is not NULL, `pResolveAttachments` must be a valid pointer to an array of `colorAttachmentCount` valid `VkAttachmentReference` structures
  - [Returns error](#)
6. If `pDepthStencilAttachment` is not NULL, `pDepthStencilAttachment` must be a valid pointer to a valid `VkAttachmentReference` structure
  - [Handled by API design](#)
7. If `preserveAttachmentCount` is not 0, `pPreserveAttachments` must be a valid pointer to an array of `preserveAttachmentCount` `uint32_t` values
  - [Handled by API design](#)

#### Validations for `VkSubpassDependency`:

1. `srcStageMask` must be a valid combination of `VkPipelineStageFlagBits` values
  - [Handled by API design \(ash\)](#)
2. `srcStageMask` must not be 0
  - [Returns error](#)
3. `dstStageMask` must be a valid combination of `VkPipelineStageFlagBits` values
  - [Handled by API design \(ash\)](#)

4. `dstStageMask` must not be 0
  - [Returns error](#)
5. `srcAccessMask` must be a valid combination of `VkAccessFlagBits` values
  - [Handled by API design \(ash\)](#)
6. `dstAccessMask` must be a valid combination of `VkAccessFlagBits` values
  - [Handled by API design \(ash\)](#)
7. `dependencyFlags` must be a valid combination of `VkDependencyFlagBits` values
  - [Handled by API design \(ash\)](#)

## Framebuffer

Validations for `vkCreateFramebuffer`:

1. `device` must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkFramebufferCreateInfo` structure
  - [Handled by API design \(ash\)](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pFramebuffer` must be a valid pointer to a `VkFramebuffer` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkFramebufferCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_FRAMEBUFFER_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL or a pointer to a valid instance of `VkFramebufferAttachmentsCreateInfo`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be a valid combination of `VkFramebufferCreateFlagBits` values
  - [Handled by API design](#)
5. `renderPass` must be a valid `VkRenderPass` handle
  - [Handled by API design](#)
6. Both of `renderPass`, and the elements of `pAttachments` that are valid handles of non-ignored parameters must have been created, allocated, or retrieved from the same `VkDevice`

## Shader

Validations for `vkCreateShaderModule`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkShaderModuleCreateInfo` structure
  - [Handled by API design](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pShaderModule` must be a valid pointer to a `VkShaderModule` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkShaderModuleCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_SHADER_MODULE_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be NULL or a pointer to a valid instance of `VkShaderModuleValidationCacheCreateInfoEXT`
  - [Handled by API design \(ash\)](#)
3. The `sType` value of each struct in the `pNext` chain must be unique
  - [Handled by API design](#)
4. `flags` must be 0
  - [Handled by API design \(ash\)](#)
5. `pCode` must be a valid pointer to an array of  $\frac{\text{codeSize}}{4}$  `uint32_t` values
  - [Handled by API design](#)

Validations for `VkVertexInputBindingDescription`:

1. `inputRate` must be a valid `VkVertexInputRate` value
  - [Handled by API design \(ash\)](#)

Validations for `VkVertexInputAttributeDescription`:

1. `format` must be a valid `VkFormat` value
  - [Handled by API design](#)

## Pipeline

Validations for `vkCreatePipelineLayout`:

1. device must be a valid `VkDevice` handle
  - [Handled by API design](#)
2. `pCreateInfo` must be a valid pointer to a valid `VkPipelineLayoutCreateInfo` structure
  - [Handled by API design](#)
3. If `pAllocator` is not NULL, `pAllocator` must be a valid pointer to a valid `VkAllocationCallbacks` structure
  - [Handled by API design](#)
4. `pPipelineLayout` must be a valid pointer to a `VkPipelineLayout` handle
  - [Handled by API design \(ash\)](#)

Validations for `VkPipelineLayoutCreateInfo`:

1. `sType` must be `VK_STRUCTURE_TYPE_PIPELINE_LAYOUT_CREATE_INFO`
  - [Handled by API design \(ash\)](#)
2. `pNext` must be `NULL`
  - [Handled by API design \(ash\)](#)
3. `flags` must be `0`
  - [Handled by API design \(ash\)](#)
4. If `setLayoutCount` is not `0`, `pSetLayouts` must be a valid pointer to an array of `setLayoutCount` valid `VkDescriptorSetLayout` handles
  - [Handled by API design](#)
5. If `pushConstantRangeCount` is not `0`, `pPushConstantRanges` must be a valid pointer to an array of `pushConstantRangeCount` valid `VkPushConstantRange` structures
  - [Handled by API design](#)

Validations for `VkPushConstantRange`:

1. `stageFlags` must be a valid combination of `VkShaderStageFlagBits` values
  - [Handled by API design \(ash\)](#)
2. `stageFlags` must not be `0`
  - [Returns error](#)

## Creation validation

Validations of correct usage in create functions as dictated by the Vulkan specification.

### Instance

Validations for `vkCreateInstance`:

1. All required extensions for each extension in the `VkInstanceCreateInfo::ppEnabledExtensionNames` list must also be present in that list.

### Device

Validations for `vkCreateDevice`:

1. All required extensions for each extension in the `VkDeviceCreateInfo::ppEnabledExtensionNames` list must also be present in that list.

Validations for `VkDeviceCreateInfo`:

1. The `queueFamilyIndex` member of each element of `pQueueCreateInfos` must be unique within `pQueueCreateInfos`, except that two members can share the same `queueFamilyIndex` if one is a protected-capable queue and one is not a protected-capable queue
2. If the `pNext` chain includes a `VkPhysicalDeviceFeatures2` structure, then `pEnabledFeatures` must be `NULL`
  - [Handled by API design](#)
3. `ppEnabledExtensionNames` must not contain `VK_AMD_negative_viewport_height`
4. `ppEnabledExtensionNames` must not contain both `VK_KHR_buffer_device_address` and `VK_EXT_buffer_device_address`

5. If the pNext chain includes a `VkPhysicalDeviceVulkan11Features` structure, then it must not include a `VkPhysicalDevice16BitStorageFeatures`, `VkPhysicalDeviceMultiviewFeatures`, `VkPhysicalDeviceVariablePointersFeatures`, `VkPhysicalDeviceProtectedMemoryFeatures`, `VkPhysicalDeviceSamplerYcbcrConversionFeatures`, or `VkPhysicalDeviceShaderDrawParametersFeatures` structure
  - [Handled by API design](#)
6. If the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then it must not include a `VkPhysicalDevice8BitStorageFeatures`, `VkPhysicalDeviceShaderAtomicInt64Features`, `VkPhysicalDeviceShaderFloat16Int8Features`, `VkPhysicalDeviceDescriptorIndexingFeatures`, `VkPhysicalDeviceScalarBlockLayoutFeatures`, `VkPhysicalDeviceImagelessFramebufferFeatures`, `VkPhysicalDeviceUniformBufferStandardLayoutFeatures`, `VkPhysicalDeviceShaderSubgroupExtendedTypesFeatures`, `VkPhysicalDeviceSeparateDepthStencilLayoutsFeatures`, `VkPhysicalDeviceHostQueryResetFeatures`, `VkPhysicalDeviceTimelineSemaphoreFeatures`, `VkPhysicalDeviceBufferDeviceAddressFeatures`, or `VkPhysicalDeviceVulkanMemoryModelFeatures` structure
  - [Handled by API design](#)
7. If `ppEnabledExtensions` contains "VK\_KHR\_draw\_indirect\_count" and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::drawIndirectCount` must be `VK_TRUE`
  - [Handled by API design](#)
8. If `ppEnabledExtensions` contains "VK\_KHR\_sampler\_mirror\_clamp\_to\_edge" and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::samplerMirrorClampToEdge` must be `VK_TRUE`
  - [Handled by API design](#)
9. If `ppEnabledExtensions` contains "VK\_EXT\_descriptor\_indexing" and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::descriptorIndexing` must be `VK_TRUE`
  - [Handled by API design](#)
10. If `ppEnabledExtensions` contains "VK\_EXT\_sampler\_filter\_minmax" and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::samplerFilterMinmax` must be `VK_TRUE`
  - [Handled by API design](#)
11. If `ppEnabledExtensions` contains "VK\_EXT\_shader\_viewport\_index\_layer" and the pNext chain includes a `VkPhysicalDeviceVulkan12Features` structure, then `VkPhysicalDeviceVulkan12Features::shaderOutputViewportIndex` and `VkPhysicalDeviceVulkan12Features::shaderOutputLayer` must both be `VK_TRUE`
  - [Handled by API design](#)

## Queue

Validations for `VkDeviceQueueCreateInfo`:

1. `queueFamilyIndex` must be less than `pQueueFamilyPropertyCount` returned by `vkGetPhysicalDeviceQueueFamilyProperties`
2. `queueCount` must be less than or equal to the `queueCount` member of the `VkQueueFamilyProperties` structure, as returned by `vkGetPhysicalDeviceQueueFamilyProperties` in the `pQueueFamilyProperties[queueFamilyIndex]`
3. Each element of `pQueuePriorities` must be between 0.0 and 1.0 inclusive

4. If the protected memory feature is not enabled, the `VK_DEVICE_QUEUE_CREATE_PROTECTED_BIT` bit of `flags` must not be set.
  - [Handled by API design](#)

## Swapchain

Validations for `VkSwapchainCreateInfoKHR`:

1. `surface` must be a surface that is supported by the device as determined using `vkGetPhysicalDeviceSurfaceSupportKHR`
2. `minImageCount` must be less than or equal to the value returned in the `maxImageCount` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface if the returned `maxImageCount` is not zero
3. If `presentMode` is not `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` nor `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`, then `minImageCount` must be greater than or equal to the value returned in the `minImageCount` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
4. `minImageCount` must be 1 if `presentMode` is either `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` or `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`
5. `imageFormat` and `imageColorSpace` must match the `format` and `colorSpace` members, respectively, of one of the `VkSurfaceFormatKHR` structures returned by `vkGetPhysicalDeviceSurfaceFormatsKHR` for the surface
6. `imageExtent` must be between `minImageExtent` and `maxImageExtent`, inclusive, where `minImageExtent` and `maxImageExtent` are members of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
7. `imageExtent` members `width` and `height` must both be non-zero
  - [Guaranteed by the type system](#)
8. `imageArrayLayers` must be greater than 0 and less than or equal to the `maxImageArrayLayers` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
  - [Lower bound guaranteed by the type system](#)
9. If `presentMode` is `VK_PRESENT_MODE_IMMEDIATE_KHR`, `VK_PRESENT_MODE_MAILBOX_KHR`, `VK_PRESENT_MODE_FIFO_KHR` or `VK_PRESENT_MODE_FIFO_RELAXED_KHR`, `imageUsage` must be a subset of the supported usage flags present in the `supportedUsageFlags` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for surface
10. If `presentMode` is `VK_PRESENT_MODE_SHARED_DEMAND_REFRESH_KHR` or `VK_PRESENT_MODE_SHARED_CONTINUOUS_REFRESH_KHR`, `imageUsage` must be a subset of the supported usage flags present in the `sharedPresentSupportedUsageFlags` member of the `VkSharedPresentSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilities2KHR` for surface
11. If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, `pQueueFamilyIndices` must be a valid pointer to an array of `queueFamilyIndexCount` `uint32_t` values
  - [Guaranteed by the type system](#)
12. If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, `queueFamilyIndexCount` must be greater than 1
  - [Guaranteed by the type system](#)
13. If `imageSharingMode` is `VK_SHARING_MODE_CONCURRENT`, each element of `pQueueFamilyIndices` must be unique and must be less than `pQueueFamilyPropertyCount`



returned by either `vkGetPhysicalDeviceQueueFamilyProperties` or `vkGetPhysicalDeviceQueueFamilyProperties2` for the `physicalDevice` that was used to create device

14. `preTransform` must be one of the bits present in the `supportedTransforms` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
15. `compositeAlpha` must be one of the bits present in the `supportedCompositeAlpha` member of the `VkSurfaceCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilitiesKHR` for the surface
16. `presentMode` must be one of the `VkPresentModeKHR` values returned by `vkGetPhysicalDeviceSurfacePresentModesKHR` for the surface
17. If the logical device was created with `VkDeviceGroupDeviceCreateInfo::physicalDeviceCount` equal to 1, `flags` must not contain `VK_SWAPCHAIN_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT_KHR`
  - [Handled by API design](#)
18. If `oldSwapchain` is not `VK_NULL_HANDLE`, `oldSwapchain` must be a non-retired swapchain associated with native window referred to by surface
  - [Handled by API design](#)
19. The implied image creation parameters of the swapchain must be supported as reported by `vkGetPhysicalDeviceImageFormatProperties`
20. If `flags` contains `VK_SWAPCHAIN_CREATE_MUTABLE_FORMAT_BIT_KHR` then the `pNext` chain must include a `VkImageFormatListCreateInfo` structure with a `viewFormatCount` greater than zero and `pViewFormats` must have an element equal to `imageFormat`
  - [Handled by API design](#)
21. If `flags` contains `VK_SWAPCHAIN_CREATE_PROTECTED_BIT_KHR`, then `VkSurfaceProtectedCapabilitiesKHR::supportsProtected` must be `VK_TRUE` in the `VkSurfaceProtectedCapabilitiesKHR` structure returned by `vkGetPhysicalDeviceSurfaceCapabilities2KHR` for surface
  - [Handled by API design](#)
22. If the `pNext` chain includes a `VkSurfaceFullScreenExclusiveInfoEXT` structure with its `fullScreenExclusive` member set to `VK_FULL_SCREEN_EXCLUSIVE_APPLICATION_CONTROLLED_EXT`, and surface was created using `vkCreateWin32SurfaceKHR`, a `VkSurfaceFullScreenExclusiveWin32InfoEXT` structure must be included in the `pNext` chain
  - [Handled by API design](#)

## Command buffer

Validations for `vkCreateCommandPool`:

1. `pCreateInfo->queueFamilyIndex` must be the index of a queue family available in the logical device.
  - [Handled by API design](#)

Validations for `VkCommandPoolCreateInfo`:

1. If the protected memory feature is not enabled, the `VK_COMMAND_POOL_CREATE_PROTECTED_BIT` bit of `flags` must not be set.
  - [Handled by API design](#)

Validations for `VkCommandBufferAllocateInfo`:

1. `commandBufferCount` must be greater than 0
  - [Guaranteed by the type system](#)

## Sempahore

Validations for `VkSemaphoreCreateInfo`:

1. If the `timelineSemaphore` feature is not enabled, `semaphoreType` must not equal `VK_SEMAPHORE_TYPE_TIMELINE`
2. If `semaphoreType` is `VK_SEMAPHORE_TYPE_BINARY`, `initialValue` must be zero.
  - [Handled by API design](#)

## Image

Validations for `vkCreateImage`:

1. If the `flags` member of `pCreateInfo` includes `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, creating this `VkImage` must not cause the total required sparse memory for all currently valid sparse resources on the device to exceed `VkPhysicalDeviceLimits::sparseAddressSpaceSize`

Validations for `VkImageCreateInfo`:

1. Each of the following values (as described in Image Creation Limits) must not be undefined `imageCreateMaxMipLevels`, `imageCreateMaxArrayLayers`, `imageCreateMaxExtent`, and `imageCreateSampleCounts`.

2. If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `pQueueFamilyIndices` must be a valid pointer to an array of `queueFamilyIndexCount` `uint32_t` values
  - [Handled by API design](#)
3. If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, `queueFamilyIndexCount` must be greater than 1
  - [Handled by API design](#)
4. If `sharingMode` is `VK_SHARING_MODE_CONCURRENT`, each element of `pQueueFamilyIndices` must be unique and must be less than `pQueueFamilyPropertyCount` returned by either `vkGetPhysicalDeviceQueueFamilyProperties` or `vkGetPhysicalDeviceQueueFamilyProperties2` for the `physicalDevice` that was used to create device
  - [Lower bound handled by API design](#)
5. If the `pNext` chain includes a `VkExternalFormatANDROID` structure, and its `externalFormat` member is non-zero the format must be `VK_FORMAT_UNDEFINED`.
  - [Handled by API design](#)
6. If the `pNext` chain does not include a `VkExternalFormatANDROID` structure, or does and its `externalFormat` member is 0, the format must not be `VK_FORMAT_UNDEFINED`.
  - [Handled by API design](#)
7. `extent.width` must be greater than 0.
  - [Guaranteed by the type system](#)
8. `extent.height` must be greater than 0.
  - [Guaranteed by the type system](#)
9. `extent.depth` must be greater than 0.
  - [Guaranteed by the type system](#)
10. `mipLevels` must be greater than 0
  - [Guaranteed by the type system](#)
11. `arrayLayers` must be greater than 0
  - [Guaranteed by the type system](#)
12. If `flags` contains `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `imageType` must be `VK_IMAGE_TYPE_2D`
  - [Guaranteed by the type system](#)
13. If `flags` contains `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `imageType` must be `VK_IMAGE_TYPE_2D`
  - [Guaranteed by the type system](#)
14. If `flags` contains `VK_IMAGE_CREATE_2D_ARRAY_COMPATIBLE_BIT`, `imageType` must be `VK_IMAGE_TYPE_3D`
  - [Guaranteed by the type system](#)
15. `extent.width` must be less than or equal to `imageCreateMaxExtent.width` (as defined in Image Creation Limits).
16. `extent.height` must be less than or equal to `imageCreateMaxExtent.height` (as defined in Image Creation Limits).
17. `extent.depth` must be less than or equal to `imageCreateMaxExtent.depth` (as defined in Image Creation Limits).
18. If `imageType` is `VK_IMAGE_TYPE_2D` and `flags` contains `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `extent.width` and `extent.height` must be equal and `arrayLayers` must be greater than or equal to 6
  - [Guaranteed by the type system](#)
19. If `imageType` is `VK_IMAGE_TYPE_1D`, both `extent.height` and `extent.depth` must be 1
  - [Guaranteed by the type system](#)
20. If `imageType` is `VK_IMAGE_TYPE_2D`, `extent.depth` must be 1
  - [Guaranteed by the type system](#)
21. `mipLevels` must be less than or equal to the number of levels in the complete mipmap chain based on `extent.width`, `extent.height`, and `extent.depth`.
  - [Guaranteed by the type system](#)

22. `mipLevels` must be less than or equal to `imageCreateMaxMipLevels` (as defined in Image Creation Limits).
23. `arrayLayers` must be less than or equal to `imageCreateMaxArrayLayers` (as defined in Image Creation Limits).
24. If `imageType` is `VK_IMAGE_TYPE_3D`, `arrayLayers` must be 1.
  - [Guaranteed by the type system](#)
25. If `samples` is not `VK_SAMPLE_COUNT_1_BIT`, then `imageType` must be `VK_IMAGE_TYPE_2D`, `flags` must not contain `VK_IMAGE_CREATE_CUBE_COMPATIBLE_BIT`, `mipLevels` must be equal to 1, and `imageCreateMaybeLinear` (as defined in Image Creation Limits) must be false,
  - [Guaranteed by the type system](#)
26. If `samples` is not `VK_SAMPLE_COUNT_1_BIT`, `usage` must not contain `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`
  - [Guaranteed by the type system](#)
27. If `usage` includes `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, then bits other than `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, and `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT` must not be set
28. If `usage` includes `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, `extent.width` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferWidth`
29. If `usage` includes `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`, `extent.height` must be less than or equal to `VkPhysicalDeviceLimits::maxFramebufferHeight`
30. If `usage` includes `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `extent.width` must be less than or equal to  $\left\lceil \frac{\text{maxFramebufferWidth}}{\text{minFragmentDensityTexelSize}_{width}} \right\rceil$
31. If `usage` includes `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `extent.height` must be less than or equal to  $\left\lceil \frac{\text{maxFramebufferHeight}}{\text{minFragmentDensityTexelSize}_{height}} \right\rceil$
32. If `usage` includes `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT`, `usage` must also contain at least one of `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`, `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`, or `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`.
33. `samples` must be a bit value that is set in `imageCreateSampleCounts` (as defined in Image Creation Limits).
34. If the multisampled storage images feature is not enabled, and `usage` contains `VK_IMAGE_USAGE_STORAGE_BIT`, `samples` must be `VK_SAMPLE_COUNT_1_BIT`
35. If the sparse bindings feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`
36. If the sparse aliased residency feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`
37. If `imageType` is `VK_IMAGE_TYPE_1D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
38. If the sparse residency for 2D images feature is not enabled, and `imageType` is `VK_IMAGE_TYPE_2D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
39. If the sparse residency for 3D images feature is not enabled, and `imageType` is `VK_IMAGE_TYPE_3D`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
40. If the sparse residency for images with 2 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_2_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`

41. If the sparse residency for images with 4 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_4_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
42. If the sparse residency for images with 8 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_8_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
43. If the sparse residency for images with 16 samples feature is not enabled, `imageType` is `VK_IMAGE_TYPE_2D`, and `samples` is `VK_SAMPLE_COUNT_16_BIT`, `flags` must not contain `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`
44. If `flags` contains `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT` or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`, it must also contain `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`
45. If any of the bits `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT` are set, `VK_IMAGE_USAGE_TRANSIENT_ATTACHMENT_BIT` must not also be set
46. If the protected memory feature is not enabled, `flags` must not contain `VK_IMAGE_CREATE_PROTECTED_BIT`.
47. If any of the bits `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT` are set, `VK_IMAGE_CREATE_PROTECTED_BIT` must not also be set.

48. If the `pNext` chain includes a `VkExternalMemoryImageCreateInfoNV` structure, it must not contain a `VkExternalMemoryImageCreateInfo` structure.
  - [Handled by API design](#)
49. If the `pNext` chain includes a `VkExternalMemoryImageCreateInfo` structure, its `handleTypes` member must only contain bits that are also in `VkExternalImageFormatProperties::externalMemoryProperties.compatibleHandleTypes`, as returned by `vkGetPhysicalDeviceImageFormatProperties2` with `format`, `imageType`, `tiling`, `usage`, and `flags` equal to those in this structure, and with a `VkPhysicalDeviceExternalImageFormatInfo` structure included in the `pNext` chain, with a `handleType` equal to any one of the handle types specified in `VkExternalMemoryImageCreateInfo::handleTypes`
  - [Handled by API design](#)
50. If the `pNext` chain includes a `VkExternalMemoryImageCreateInfoNV` structure, its `handleTypes` member must only contain bits that are also in `VkExternalImageFormatPropertiesNV::externalMemoryProperties.compatibleHandleTypes`, as returned by `vkGetPhysicalDeviceExternalImageFormatPropertiesNV` with `format`, `imageType`, `tiling`, `usage`, and `flags` equal to those in this structure, and with `externalHandleType` equal to any one of the handle types specified in `VkExternalMemoryImageCreateInfoNV::handleTypes`
  - [Handled by API design](#)

51. If the logical device was created with `VkDeviceGroupDeviceCreateInfo::physicalDeviceCount` equal to 1, `flags` must not contain `VK_IMAGE_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT`
52. If `flags` contains `VK_IMAGE_CREATE_SPLIT_INSTANCE_BIND_REGIONS_BIT`, then `mipLevels` must be one, `arrayLayers` must be one, `imageType` must be `VK_IMAGE_TYPE_2D`, and `imageCreateMaybeLinear` (as defined in Image Creation Limits) must be false.
53. If `flags` contains `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT`, then `format` must be a block-compressed image format, an ETC compressed image format, or an ASTC compressed image format.
54. If `flags` contains `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT`, then `flags` must also contain `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT`.

55. `initialLayout` must be `VK_IMAGE_LAYOUT_UNDEFINED` or `VK_IMAGE_LAYOUT_PREINITIALIZED`.
  - [Guaranteed by the type system](#)
56. If the `pNext` chain includes a `VkExternalMemoryImageCreateInfo` or `VkExternalMemoryImageCreateInfoNV`
  - [Handled by API design](#)

57. If the image format is one of those listed in Formats requiring sampler Y<sub>2</sub>CBCRconversion for VK\_IMAGE\_ASPECT\_COLOR\_BIT image views, then mipLevels must be 1
58. If the image format is one of those listed in Formats requiring sampler Y<sub>2</sub>CBCRconversion for VK\_IMAGE\_ASPECT\_COLOR\_BIT image views, samples must be VK\_SAMPLE\_COUNT\_1\_BIT
59. If the image format is one of those listed in Formats requiring sampler Y<sub>2</sub>CBCRconversion for VK\_IMAGE\_ASPECT\_COLOR\_BIT image views, imageType must be VK\_IMAGE\_TYPE\_2D
60. If the image format is one of those listed in Formats requiring sampler Y<sub>2</sub>CBCRconversion for VK\_IMAGE\_ASPECT\_COLOR\_BIT image views, and the ycbcrImageArrays feature is not enabled, arrayLayers must be 1
61. If format is a *multi-planar* format, and if imageCreateFormatFeatures (as defined in Image Creation Limits) does not contain VK\_FORMAT\_FEATURE\_DISJOINT\_BIT, then flags must not contain VK\_IMAGE\_CREATE\_DISJOINT\_BIT
62. If format is not a *multi-planar* format, and flags does not include VK\_IMAGE\_CREATE\_ALIAS\_BIT, flags must not contain VK\_IMAGE\_CREATE\_DISJOINT\_BIT
63. If tiling is VK\_IMAGE\_TILING\_DRM\_FORMAT\_MODIFIER\_EXT, then the pNext chain must include exactly one of VkImageDrmFormatModifierListCreateInfoEXT or VkImageDrmFormatModifierExplicitCreateInfoEXT structures
64. If the pNext chain includes a VkImageDrmFormatModifierListCreateInfoEXT or VkImageDrmFormatModifierExplicitCreateInfoEXT structure, then tiling must be VK\_IMAGE\_TILING\_DRM\_FORMAT\_MODIFIER\_EXT
  - [Handled by API design](#)
65. If tiling is VK\_IMAGE\_TILING\_DRM\_FORMAT\_MODIFIER\_EXT and flags contains VK\_IMAGE\_CREATE\_MUTABLE\_FORMAT\_BIT, then the pNext chain must include a VkImageFormatListCreateInfo structure with non-zero viewFormatCount.
66. If flags contains VK\_IMAGE\_CREATE\_SAMPLE\_LOCATIONS\_COMPATIBLE\_DEPTH\_BIT\_EXT format must be a depth or depth/stencil format
67. If the pNext chain includes a VkExternalMemoryImageCreateInfo structure whose handleTypes member includes VK\_EXTERNAL\_MEMORY\_HANDLE\_TYPE\_ANDROID\_HARDWARE\_BUFFER\_BIT\_ANDROID, imageType must be VK\_IMAGE\_TYPE\_2D.
  - [Handled by API design](#)
68. If the pNext chain includes a VkExternalMemoryImageCreateInfo structure whose handleTypes member includes VK\_EXTERNAL\_MEMORY\_HANDLE\_TYPE\_ANDROID\_HARDWARE\_BUFFER\_BIT\_ANDROID, mipLevels must either be 1 or equal to the number of levels in the complete mipmap chain based on extent.width, extent.height, and extent.depth.
  - [Handled by API design](#)
69. If the pNext chain includes a VkExternalFormatANDROID structure whose externalFormat member is not 0, flags must not include VK\_IMAGE\_CREATE\_MUTABLE\_FORMAT\_BIT.
  - [Handled by API design](#)
70. If the pNext chain includes a VkExternalFormatANDROID structure whose externalFormat member is not 0, usage must not include any usages except VK\_IMAGE\_USAGE\_SAMPLED\_BIT.
  - [Handled by API design](#)
71. If the pNext chain includes a VkExternalFormatANDROID structure whose externalFormat member is not 0, tiling must be VK\_IMAGE\_TILING\_OPTIMAL.
  - [Handled by API design](#)
72. If format is a depth-stencil format, usage includes VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT, and the pNext chain includes a VkImageStencilUsageCreateInfo structure, then its VkImageStencilUsageCreateInfo::stencilUsage member must also include VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT
73. If format is a depth-stencil format, usage does not include VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT, and the pNext chain includes a



- VkImageStencilUsageCreateInfo structure, then its  
VkImageStencilUsageCreateInfo::stencilUsage member must also not include  
VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT
74. If format is a depth-stencil format, usage includes  
VK\_IMAGE\_USAGE\_TRANSIENT\_ATTACHMENT\_BIT, and the pNext chain includes a  
VkImageStencilUsageCreateInfo structure, then its  
VkImageStencilUsageCreateInfo::stencilUsage member must also include  
VK\_IMAGE\_USAGE\_TRANSIENT\_ATTACHMENT\_BIT
  75. If format is a depth-stencil format, usage does not include  
VK\_IMAGE\_USAGE\_TRANSIENT\_ATTACHMENT\_BIT, and the pNext chain includes a  
VkImageStencilUsageCreateInfo structure, then its  
VkImageStencilUsageCreateInfo::stencilUsage member must also not include  
VK\_IMAGE\_USAGE\_TRANSIENT\_ATTACHMENT\_BIT
  76. If Format is a depth-stencil format and the pNext chain includes a  
VkImageStencilUsageCreateInfo structure with its stencilUsage member including  
VK\_IMAGE\_USAGE\_INPUT\_ATTACHMENT\_BIT, extent.width must be less than or equal to  
VkPhysicalDeviceLimits::maxFramebufferWidth
  77. If format is a depth-stencil format and the pNext chain includes a  
VkImageStencilUsageCreateInfo structure with its stencilUsage member including  
VK\_IMAGE\_USAGE\_INPUT\_ATTACHMENT\_BIT, extent.height must be less than or equal to  
VkPhysicalDeviceLimits::maxFramebufferHeight
  78. If the multisampled storage images feature is not enabled, format is a depth-stencil format and  
the pNext chain includes a VkImageStencilUsageCreateInfo structure with its  
stencilUsage including VK\_IMAGE\_USAGE\_STORAGE\_BIT, samples must be  
VK\_SAMPLE\_COUNT\_1\_BIT
  79. If flags contains VK\_IMAGE\_CREATE\_CORNER\_SAMPLED\_BIT\_NV, imageType must be  
VK\_IMAGE\_TYPE\_2D or VK\_IMAGE\_TYPE\_3D
  80. If flags contains VK\_IMAGE\_CREATE\_CORNER\_SAMPLED\_BIT\_NV, it must not contain  
VK\_IMAGE\_CREATE\_CUBE\_COMPATIBLE\_BIT and the format must not be a depth/stencil format
  81. If flags contains VK\_IMAGE\_CREATE\_CORNER\_SAMPLED\_BIT\_NV and imageType is  
VK\_IMAGE\_TYPE\_2D, extent.width and extent.height must be greater than 1
  82. If flags contains VK\_IMAGE\_CREATE\_CORNER\_SAMPLED\_BIT\_NV and imageType is  
VK\_IMAGE\_TYPE\_3D, extent.width, extent.height, and extent.depth must be greater than  
1
  83. If usage includes VK\_IMAGE\_USAGE\_SHADING\_RATE\_IMAGE\_BIT\_NV, imageType must be  
VK\_IMAGE\_TYPE\_2D.
  84. If usage includes VK\_IMAGE\_USAGE\_SHADING\_RATE\_IMAGE\_BIT\_NV, samples must be  
VK\_SAMPLE\_COUNT\_1\_BIT.
  85. If usage includes VK\_IMAGE\_USAGE\_SHADING\_RATE\_IMAGE\_BIT\_NV, tiling must be  
VK\_IMAGE\_TILING\_OPTIMAL.
  86. If flags contains VK\_IMAGE\_CREATE\_SUBSAMPLED\_BIT\_EXT, tiling must be  
VK\_IMAGE\_TILING\_OPTIMAL
  87. If flags contains VK\_IMAGE\_CREATE\_SUBSAMPLED\_BIT\_EXT, imageType must be  
VK\_IMAGE\_TYPE\_2D
  88. If flags contains VK\_IMAGE\_CREATE\_SUBSAMPLED\_BIT\_EXT, flags must not contain  
VK\_IMAGE\_CREATE\_CUBE\_COMPATIBLE\_BIT
  89. If flags contains VK\_IMAGE\_CREATE\_SUBSAMPLED\_BIT\_EXT, mipLevels must be 1

#### Validations for VkImageViewCreateInfo:

1. If image was not created with VK\_IMAGE\_CREATE\_CUBE\_COMPATIBLE\_BIT then viewType must  
not be VK\_IMAGE\_VIEW\_TYPE\_CUBE or VK\_IMAGE\_VIEW\_TYPE\_CUBE\_ARRAY
2. If the image cubemap arrays feature is not enabled, viewType must not be  
VK\_IMAGE\_VIEW\_TYPE\_CUBE\_ARRAY
3. If image was created with VK\_IMAGE\_TYPE\_3D but without

- VK\_IMAGE\_CREATE\_2D\_ARRAY\_COMPATIBLE\_BIT set then viewType must not be VK\_IMAGE\_VIEW\_TYPE\_2D or VK\_IMAGE\_VIEW\_TYPE\_2D\_ARRAY
4. image must have been created with a usage value containing at least one of VK\_IMAGE\_USAGE\_SAMPLED\_BIT, VK\_IMAGE\_USAGE\_STORAGE\_BIT, VK\_IMAGE\_USAGE\_COLOR\_ATTACHMENT\_BIT, VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT, VK\_IMAGE\_USAGE\_INPUT\_ATTACHMENT\_BIT, VK\_IMAGE\_USAGE\_SHADING\_RATE\_IMAGE\_BIT\_NV, or VK\_IMAGE\_USAGE\_FRAGMENT\_DENSITY\_MAP\_BIT\_EXT
  5. The format features of the resultant image view must contain at least one bit.
  6. If usage contains VK\_IMAGE\_USAGE\_SAMPLED\_BIT, then the format features of the resultant image view must contain VK\_FORMAT\_FEATURE\_SAMPLED\_IMAGE\_BIT.
  7. If usage contains VK\_IMAGE\_USAGE\_STORAGE\_BIT, then the image view's format features must contain VK\_FORMAT\_FEATURE\_STORAGE\_IMAGE\_BIT.
  8. If usage contains VK\_IMAGE\_USAGE\_COLOR\_ATTACHMENT\_BIT, then the image view's format features must contain VK\_FORMAT\_FEATURE\_COLOR\_ATTACHMENT\_BIT.
  9. If usage contains VK\_IMAGE\_USAGE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT, then the image view's format features must contain VK\_FORMAT\_FEATURE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT.
  10. If usage contains VK\_IMAGE\_USAGE\_INPUT\_ATTACHMENT\_BIT, then the image view's format features must contain at least one of VK\_FORMAT\_FEATURE\_COLOR\_ATTACHMENT\_BIT or VK\_FORMAT\_FEATURE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT.
  11. subresourceRange.baseMipLevel must be less than the mipLevels specified in VkImageCreateInfo when image was created
  12. If subresourceRange.levelCount is not VK\_REMAINING\_MIP\_LEVELS, subresourceRange.baseMipLevel+subresourceRange.levelCount must be less than or equal to the mipLevels specified in VkImageCreateInfo when image was created
  13. If image was created with usage containing VK\_IMAGE\_USAGE\_FRAGMENT\_DENSITY\_MAP\_BIT\_EXT, subresourceRange.levelCount must be 1
  14. If image is not a 3D image created with VK\_IMAGE\_CREATE\_2D\_ARRAY\_COMPATIBLE\_BIT set, or viewType is not VK\_IMAGE\_VIEW\_TYPE\_2D or VK\_IMAGE\_VIEW\_TYPE\_2D\_ARRAY, subresourceRange.baseArrayLayer must be less than the arrayLayers specified in VkImageCreateInfo when image was created
  15. If subresourceRange.layerCount is not VK\_REMAINING\_ARRAY\_LAYERS, image is not a 3D image created with VK\_IMAGE\_CREATE\_2D\_ARRAY\_COMPATIBLE\_BIT set, or viewType is not VK\_IMAGE\_VIEW\_TYPE\_2D or VK\_IMAGE\_VIEW\_TYPE\_2D\_ARRAY, subresourceRange.layerCount must be non-zero and subresourceRange.baseArrayLayer+subresourceRange.layerCount must be less than or equal to the arrayLayers specified in VkImageCreateInfo when image was created
  16. If image is a 3D image created with VK\_IMAGE\_CREATE\_2D\_ARRAY\_COMPATIBLE\_BIT set, and viewType is VK\_IMAGE\_VIEW\_TYPE\_2D or VK\_IMAGE\_VIEW\_TYPE\_2D\_ARRAY, subresourceRange.baseArrayLayer must be less than the depth computed from baseMipLevel and extent.depth specified in VkImageCreateInfo when image was created, according to the formula defined in Image Miplevel Sizing.
  17. If subresourceRange.layerCount is not VK\_REMAINING\_ARRAY\_LAYERS, image is a 3D image created with VK\_IMAGE\_CREATE\_2D\_ARRAY\_COMPATIBLE\_BIT set, and viewType is VK\_IMAGE\_VIEW\_TYPE\_2D or VK\_IMAGE\_VIEW\_TYPE\_2D\_ARRAY, subresourceRange.layerCount must be non-zero and subresourceRange.baseArrayLayer+subresourceRange.layerCount must be less than or equal to the depth computed from baseMipLevel and extent.depth specified in VkImageCreateInfo when image was created, according to the formula defined in Image Miplevel Sizing.
  18. If image was created with the VK\_IMAGE\_CREATE\_MUTABLE\_FORMAT\_BIT flag, but without the VK\_IMAGE\_CREATE\_BLOCK\_TEXEL\_VIEW\_COMPATIBLE\_BIT flag, and if the format of the image is not a multi-planar format, format must be compatible with the format used to create image, as defined in Format Compatibility Classes



19. If image was created with the `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT` flag, format must be compatible with, or must be an uncompressed format that is size-compatible with, the format used to create image.
20. If image was created with the `VK_IMAGE_CREATE_BLOCK_TEXEL_VIEW_COMPATIBLE_BIT` flag, the `levelCount` and `layerCount` members of `subresourceRange` must both be 1.
21. If a `VkImageFormatListCreateInfo` structure was included in the `pNext` chain of the `VkImageCreateInfo` structure used when creating image and the `viewFormatCount` field of `VkImageFormatListCreateInfo` is not zero then format must be one of the formats in `VkImageFormatListCreateInfo::pViewFormats`.
22. If image was created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, if the format of the image is a multi-planar format, and if `subresourceRange.aspectMask` is one of `VK_IMAGE_ASPECT_PLANE_0_BIT`, `VK_IMAGE_ASPECT_PLANE_1_BIT`, or `VK_IMAGE_ASPECT_PLANE_2_BIT`, then format must be compatible with the `VkFormat` for the plane of the image format indicated by `subresourceRange.aspectMask`, as defined in Compatible formats of planes of multi-planar formats
23. If image was not created with the `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT` flag, or if the format of the image is a multi-planar format and if `subresourceRange.aspectMask` is `VK_IMAGE_ASPECT_COLOR_BIT`, format must be identical to the format used to create image
24. If the `pNext` chain includes a `VkSamplerYcbcrConversionInfo` structure with a `conversion` value other than `VK_NULL_HANDLE`, all members of `components` must have the value `VK_COMPONENT_SWIZZLE_IDENTITY`.
25. If image is non-sparse then it must be bound completely and contiguously to a single `VkDeviceMemory` object
26. `subresourceRange` and `viewType` must be compatible with the image, as described in the compatibility table
27. If image has an external format, format must be `VK_FORMAT_UNDEFINED`.
28. If image has an external format, the `pNext` chain must include a `VkSamplerYcbcrConversionInfo` structure with a `conversion` object created with the same external format as image.
29. If image has an external format, all members of `components` must be `VK_COMPONENT_SWIZZLE_IDENTITY`.
30. If image was created with usage containing `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, `viewType` must be `VK_IMAGE_VIEW_TYPE_2D` or `VK_IMAGE_VIEW_TYPE_2D_ARRAY`
31. If image was created with usage containing `VK_IMAGE_USAGE_SHADING_RATE_IMAGE_BIT_NV`, format must be `VK_FORMAT_R8_UINT`
32. If dynamic fragment density map feature is not enabled, `flags` must not contain `VK_IMAGE_VIEW_CREATE_FRAGMENT_DENSITY_MAP_DYNAMIC_BIT_EXT`
33. If dynamic fragment density map feature is not enabled and image was created with usage containing `VK_IMAGE_USAGE_FRAGMENT_DENSITY_MAP_BIT_EXT`, `flags` must not contain any of `VK_IMAGE_CREATE_PROTECTED_BIT`, `VK_IMAGE_CREATE_SPARSE_BINDING_BIT`, `VK_IMAGE_CREATE_SPARSE_RESIDENCY_BIT`, or `VK_IMAGE_CREATE_SPARSE_ALIASED_BIT`
34. If the `pNext` chain includes a `VkImageViewUsageCreateInfo` structure, and image was not created with a `VkImageStencilUsageCreateInfo` structure included in the `pNext` chain of `VkImageCreateInfo`, its `usage` member must not include any bits that were not set in the `usage` member of the `VkImageCreateInfo` structure used to create image

35. If the pNext chain includes a `VkImageViewUsageCreateInfo` structure, image was created with a `VkImageStencilUsageCreateInfo` structure included in the pNext chain of `VkImageCreateInfo`, and `subResourceRange.aspectMask` includes `VK_IMAGE_ASPECT_STENCIL_BIT`, the usage member of the `VkImageViewUsageCreateInfo` instance must not include any bits that were not set in the usage member of the `VkImageStencilUsageCreateInfo` structure used to create image
  - [Handled by API design](#)
36. If the pNext chain includes a `VkImageViewUsageCreateInfo` structure, image was created with a `VkImageStencilUsageCreateInfo` structure included in the pNext chain of `VkImageCreateInfo`, and `subResourceRange.aspectMask` includes bits other than `VK_IMAGE_ASPECT_STENCIL_BIT`, the usage member of the `VkImageViewUsageCreateInfo` structure must not include any bits that were not set in the usage member of the `VkImageCreateInfo` structure used to create image
  - [Handled by API design](#)
37. If `viewType` is `VK_IMAGE_VIEW_TYPE_CUBE` and `subresourceRange.layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, `subresourceRange.layerCount` must be 6
  - [Handled by API design](#)
38. If `viewType` is `VK_IMAGE_VIEW_TYPE_CUBE_ARRAY` and `subresourceRange.layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, `subresourceRange.layerCount` must be a multiple of 6
39. If `viewType` is `VK_IMAGE_VIEW_TYPE_CUBE` and `subresourceRange.layerCount` is `VK_REMAINING_ARRAY_LAYERS`, the remaining number of layers must be 6
40. If `viewType` is `VK_IMAGE_VIEW_TYPE_CUBE_ARRAY` and `subresourceRange.layerCount` is `VK_REMAINING_ARRAY_LAYERS`, the remaining number of layers must be a multiple of 6

Validations for `VkImageSubresourceRange`:

1. If `levelCount` is not `VK_REMAINING_MIP_LEVELS`, it must be greater than 0
  - [Guaranteed by the type system](#)
2. If `layerCount` is not `VK_REMAINING_ARRAY_LAYERS`, it must be greater than 0
  - [Guaranteed by the type system](#)
3. If `aspectMask` includes `VK_IMAGE_ASPECT_COLOR_BIT`, then it must not include any of `VK_IMAGE_ASPECT_PLANE_0_BIT`, `VK_IMAGE_ASPECT_PLANE_1_BIT`, or `VK_IMAGE_ASPECT_PLANE_2_BIT`
4. `aspectMask` must not include `VK_IMAGE_ASPECT_MEMORY_PLANE_i_BIT_EXT` for any index `i`

## Buffer

Validations for `vkCreateBuffer`:

1. If the `flags` member of `pCreateInfo` includes `VK_BUFFER_CREATE_SPARSE_BINDING_BIT`, creating this `VkBuffer` must not cause the total required sparse memory for all currently valid sparse resources on the device to exceed `VkPhysicalDeviceLimits::sparseAddressSpaceSize`

Validations for `VkBufferCreateInfo`:

1. size must be greater than 0
  - [Guaranteed by the type system](#)
2. If sharingMode is VK\_SHARING\_MODE\_CONCURRENT, pQueueFamilyIndices must be a valid pointer to an array of queueFamilyIndexCount uint32\_t values
  - [Handled by API design](#)
3. If sharingMode is VK\_SHARING\_MODE\_CONCURRENT, queueFamilyIndexCount must be greater than 1
  - [Handled by API design](#)
4. If sharingMode is VK\_SHARING\_MODE\_CONCURRENT, each element of pQueueFamilyIndices must be unique and must be less than pQueueFamilyPropertyCount returned by either vkGetPhysicalDeviceQueueFamilyProperties or vkGetPhysicalDeviceQueueFamilyProperties2 for the physicalDevice that was used to create device
  - [Handled by API design](#)
5. If the sparse bindings feature is not enabled, flags must not contain VK\_BUFFER\_CREATE\_SPARSE\_BINDING\_BIT
6. If the sparse buffer residency feature is not enabled, flags must not contain VK\_BUFFER\_CREATE\_SPARSE\_RESIDENCY\_BIT
7. If the sparse aliased residency feature is not enabled, flags must not contain VK\_BUFFER\_CREATE\_SPARSE\_ALIASED\_BIT
8. If flags contains VK\_BUFFER\_CREATE\_SPARSE\_RESIDENCY\_BIT or VK\_BUFFER\_CREATE\_SPARSE\_ALIASED\_BIT, it must also contain VK\_BUFFER\_CREATE\_SPARSE\_BINDING\_BIT
9. If the pNext chain includes a VkExternalMemoryBufferCreateInfo structure, its handleTypes member must only contain bits that are also in VkExternalBufferProperties::externalMemoryProperties.compatibleHandleTypes, as returned by vkGetPhysicalDeviceExternalBufferProperties with pExternalBufferInfo→handleType equal to any one of the handle types specified in VkExternalMemoryBufferCreateInfo::handleTypes
10. If the protected memory feature is not enabled, flags must not contain VK\_BUFFER\_CREATE\_PROTECTED\_BIT
11. If any of the bits VK\_BUFFER\_CREATE\_SPARSE\_BINDING\_BIT, VK\_BUFFER\_CREATE\_SPARSE\_RESIDENCY\_BIT, or VK\_BUFFER\_CREATE\_SPARSE\_ALIASED\_BIT are set, VK\_BUFFER\_CREATE\_PROTECTED\_BIT must not also be set
12. If the pNext chain includes a VkDedicatedAllocationBufferCreateInfoNV structure, and the dedicatedAllocation member of the chained structure is VK\_TRUE, then flags must not include VK\_BUFFER\_CREATE\_SPARSE\_BINDING\_BIT, VK\_BUFFER\_CREATE\_SPARSE\_RESIDENCY\_BIT, or VK\_BUFFER\_CREATE\_SPARSE\_ALIASED\_BIT
13. If VkBufferDeviceAddressCreateInfoEXT::deviceAddress is not zero, flags must include VK\_BUFFER\_CREATE\_DEVICE\_ADDRESS\_CAPTURE\_REPLAY\_BIT
14. If VkBufferOpaqueCaptureAddressCreateInfo::opaqueCaptureAddress is not zero, flags must include VK\_BUFFER\_CREATE\_DEVICE\_ADDRESS\_CAPTURE\_REPLAY\_BIT
15. If flags includes VK\_BUFFER\_CREATE\_DEVICE\_ADDRESS\_CAPTURE\_REPLAY\_BIT, the bufferDeviceAddressCaptureReplay or VkPhysicalDeviceBufferDeviceAddressFeaturesEXT::bufferDeviceAddressCaptureReplay feature must be enabled

Validations for VkBufferViewCreateInfo:

1. offset must be less than the size of buffer
2. If range is not equal to VK\_WHOLE\_SIZE, range must be greater than 0
  - [Guaranteed by the type system](#)
3. If range is not equal to VK\_WHOLE\_SIZE, range must be an integer multiple of the texel block size of format

4. If `range` is not equal to `VK_WHOLE_SIZE`, `range` divided by the texel block size of `format`, multiplied by the number of texels per texel block for that format (as defined in the Compatible Formats table), must be less than or equal to `VkPhysicalDeviceLimits::maxTexelBufferElements`
5. If `range` is not equal to `VK_WHOLE_SIZE`, the sum of `offset` and `range` must be less than or equal to the size of `buffer`
6. `buffer` must have been created with a `usage` value containing at least one of `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT` or `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`
7. If `buffer` was created with `usage` containing `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT`, `format` must be supported for uniform texel buffers, as specified by the `VK_FORMAT_FEATURE_UNIFORM_TEXEL_BUFFER_BIT` flag in `VkFormatProperties::bufferFeatures` returned by `vkGetPhysicalDeviceFormatProperties`
8. If `buffer` was created with `usage` containing `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`, `format` must be supported for storage texel buffers, as specified by the `VK_FORMAT_FEATURE_STORAGE_TEXEL_BUFFER_BIT` flag in `VkFormatProperties::bufferFeatures` returned by `vkGetPhysicalDeviceFormatProperties`
9. If `buffer` is non-sparse then it must be bound completely and contiguously to a single `VkDeviceMemory` object
10. If the `texelBufferAlignment` feature is not enabled, `offset` must be a multiple of `VkPhysicalDeviceLimits::minTexelBufferOffsetAlignment`
11. If the `texelBufferAlignment` feature is enabled and if `buffer` was created with `usage` containing `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT`, `offset` must be a multiple of the lesser of `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::storageTexelBufferOffsetAlignmentBytes` or, if `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::storageTexelBufferOffsetSingleTexelAlignment` is `VK_TRUE`, the size of a texel of the requested `format`. If the size of a texel is a multiple of three bytes, then the size of a single component of `format` is used instead
12. If the `texelBufferAlignment` feature is enabled and if `buffer` was created with `usage` containing `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT`, `offset` must be a multiple of the lesser of `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::uniformTexelBufferOffsetAlignmentBytes` or, if `VkPhysicalDeviceTexelBufferAlignmentPropertiesEXT::uniformTexelBufferOffsetSingleTexelAlignment` is `VK_TRUE`, the size of a texel of the requested `format`. If the size of a texel is a multiple of three bytes, then the size of a single component of `format` is used instead

## Descriptor

Validations for `VkDescriptorSetLayoutCreateInfo`:

1. The `VkDescriptorSetLayoutBinding::binding` members of the elements of the `pBindings` array must each have different values.
  - [Handled by API design](#)
2. If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR`, then all elements of `pBindings` must not have a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`
3. If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR`, then all elements of `pBindings` must not have a `descriptorType` of

VK\_DESCRIPTOR\_TYPE\_INLINE\_UNIFORM\_BLOCK\_EXT

4. If `flags` contains `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR`, then the total number of elements of all bindings must be less than or equal to `VkPhysicalDevicePushDescriptorPropertiesKHR::maxPushDescriptors`
5. If any binding has the `VK_DESCRIPTOR_BINDING_UPDATE_AFTER_BIND_BIT` bit set, `flags` must include `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT`
6. If any binding has the `VK_DESCRIPTOR_BINDING_UPDATE_AFTER_BIND_BIT` bit set, then all bindings must not have `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`

#### Validations for `VkDescriptorSetLayoutBinding`:

1. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLER` or `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, and `descriptorCount` is not 0 and `pImmutableSamplers` is not NULL, `pImmutableSamplers` must be a valid pointer to an array of `descriptorCount` valid `VkSampler` handles
  - [Handled by API design](#)
2. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` then `descriptorCount` must be a multiple of 4
  - [Handled by API design](#)
3. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` then `descriptorCount` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxInlineUniformBlockSize`
4. If `descriptorCount` is not 0, `stageFlags` must be a valid combination of `VkShaderStageFlagBits` values
5. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` and `descriptorCount` is not 0, then `stageFlags` must be 0 or `VK_SHADER_STAGE_FRAGMENT_BIT`
  - [Handled by API design](#)

#### Validations for `VkDescriptorPoolCreateInfo`:

1. `maxSets` must be greater than 0
  - [Guaranteed by the type system](#)

#### Validations for `VkSamplerCreateInfo`:

1. The absolute value of `mipLodBias` must be less than or equal to `VkPhysicalDeviceLimits::maxSamplerLodBias`
2. `maxLod` must be greater than or equal to `minLod`
3. If the anisotropic sampling feature is not enabled, `anisotropyEnable` must be `VK_FALSE`
  - [Handled by API design](#)
4. If `anisotropyEnable` is `VK_TRUE`, `maxAnisotropy` must be between 1.0 and `VkPhysicalDeviceLimits::maxSamplerAnisotropy`, inclusive
5. If sampler `Y2CBCR` conversion is enabled and the sampler `Y2CBCR` conversion's features do not support `VK_FORMAT_FEATURE_SAMPLED_IMAGE_YCBCR_CONVERSION_SEPARATE_RECONSTRUCTION_FILTER_BIT`, `minFilter` and `magFilter` must be equal to the sampler `Y2CC` conversion's `chromaFilter`

6. If `unnormalizedCoordinates` is `VK_TRUE`, `minFilter` and `magFilter` must be equal
  - [Handled by API design](#)
7. If `unnormalizedCoordinates` is `VK_TRUE`, `mipmapMode` must be `VK_SAMPLER_MIPMAP_MODE_NEAREST`
  - [Handled by API design](#)
8. If `unnormalizedCoordinates` is `VK_TRUE`, `minLod` and `maxLod` must be zero
  - [Handled by API design](#)
9. If `unnormalizedCoordinates` is `VK_TRUE`, `addressModeU` and `addressModeV` must each be either `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_EDGE` or `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_BORDER`
  - [Handled by API design](#)
10. If `unnormalizedCoordinates` is `VK_TRUE`, `anisotropyEnable` must be `VK_FALSE`
  - [Handled by API design](#)
11. If `unnormalizedCoordinates` is `VK_TRUE`, `compareEnable` must be `VK_FALSE`
  - [Handled by API design](#)
12. If any of `addressModeU`, `addressModeV` or `addressModeW` are `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_BORDER`, `borderColor` must be a valid `VkBorderColor` value
13. If sampler `YCBCRConversion` is enabled, `addressModeU`, `addressModeV`, and `addressModeW` must be `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_EDGE`, `anisotropyEnable` must be `VK_FALSE`, and `unnormalizedCoordinates` must be `VK_FALSE`
14. The sampler reduction mode must be set to `VK_SAMPLER_REDUCTION_MODE_WEIGHTED_AVERAGE` if sampler `YCBCRConversion` is enabled
15. If `samplerMirrorClampToEdge` is not enabled, and if the `VK_KHR_sampler_mirror_clamp_to_e`
16. If `compareEnable` is `VK_TRUE`, `compareOp` must be a valid `VkCompareOp` value
17. If either `magFilter` or `minFilter` is `VK_FILTER_CUBIC_EXT`, `anisotropyEnable` must be `VK_FALSE`
18. If `compareEnable` is `VK_TRUE`, the `reductionMode` member of `VkSamplerReductionModeCreateInfo` must be `VK_SAMPLER_REDUCTION_MODE_WEIGHTED_AVERAGE`
19. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `minFilter` and `magFilter` must be equal.
  - [Handled by API design](#)
20. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `mipmapMode` must be `VK_SAMPLER_MIPMAP_MODE_NEAREST`.
  - [Handled by API design](#)
21. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `minLod` and `maxLod` must be zero.
  - [Handled by API design](#)
22. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `addressModeU` and `addressModeV` must each be either `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_EDGE` or `VK_SAMPLER_ADDRESS_MODE_CLAMP_TO_BORDER`.
  - [Handled by API design](#)
23. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `anisotropyEnable` must be `VK_FALSE`.
  - [Handled by API design](#)
24. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `compareEnable` must be `VK_FALSE`.
  - [Handled by API design](#)
25. If `flags` includes `VK_SAMPLER_CREATE_SUBSAMPLED_BIT_EXT`, then `unnormalizedCoordinates` must be `VK_FALSE`.
  - [Handled by API design](#)



## Render pass

Validations for `VkRenderPassCreateInfo`:

1. If the `attachment` member of any element of `pInputAttachments`, `pColorAttachments`, `pResolveAttachments` or `pDepthStencilAttachment`, or any element of `pPreserveAttachments` in any element of `pSubpasses` is not `VK_ATTACHMENT_UNUSED`, it must be less than `attachmentCount`
2. For any member of `pAttachments` with a `loadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a layout equal to `VK_IMAGE_LAYOUT_SHADER_READ_ONLY_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`.
3. For any member of `pAttachments` with a `stencilLoadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a layout equal to `VK_IMAGE_LAYOUT_SHADER_READ_ONLY_OPTIMAL` or `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`.
4. For any member of `pAttachments` with a `loadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a layout equal to `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`.
5. For any member of `pAttachments` with a `stencilLoadOp` equal to `VK_ATTACHMENT_LOAD_OP_CLEAR`, the first use of that attachment must not specify a layout equal to `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`.
6. If the `pNext` chain includes a `VkRenderPassInputAttachmentAspectCreateInfo` structure, the `subpass` member of each element of its `pAspectReferences` member must be less than `subpassCount`
7. If the `pNext` chain includes a `VkRenderPassInputAttachmentAspectCreateInfo` structure, the `inputAttachmentIndex` member of each element of its `pAspectReferences` member must be less than the value of `inputAttachmentCount` in the member of `pSubpasses` identified by its `subpass` member
8. If the `pNext` chain includes a `VkRenderPassInputAttachmentAspectCreateInfo` structure, for any element of the `pInputAttachments` member of any element of `pSubpasses` where the `attachment` member is not `VK_ATTACHMENT_UNUSED`, the `aspectMask` member of the corresponding element of `VkRenderPassInputAttachmentAspectCreateInfo::pAspectReferences` must only include aspects that are present in images of the format specified by the element of `pAttachments` at `attachment`
9. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, and its `subpassCount` member is not zero, that member must be equal to the value of `subpassCount`
10. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, if its `dependencyCount` member is not zero, it must be equal to `dependencyCount`
11. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, for each non-zero element of `pViewOffsets`, the `srcSubpass` and `dstSubpass` members of `pDependencies` at the same index must not be equal
12. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, for any element of `pDependencies` with a `dependencyFlags` member that does not include `VK_DEPENDENCY_VIEW_LOCAL_BIT`, the corresponding element of the `pViewOffsets` member of that `VkRenderPassMultiviewCreateInfo` instance must be 0
13. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, elements of its `pViewMasks` member must either all be 0, or all not be 0
14. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, and each element of its `pViewMasks` member is 0, the `dependencyFlags` member of each element of `pDependencies` must not include `VK_DEPENDENCY_VIEW_LOCAL_BIT`
15. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, and each element of its `pViewMasks` member is 0, `correlatedViewMaskCount` must be 0
16. If the `pNext` chain includes a `VkRenderPassMultiviewCreateInfo` structure, each element of its `pViewMask` member must not have a bit set at an index greater than or equal to

VkPhysicalDeviceLimits::maxFramebufferLayers

17. For any element of `pDependencies`, if the `srcSubpass` is not `VK_SUBPASS_EXTERNAL`, all stage flags included in the `srcStageMask` member of that dependency must be a pipeline stage supported by the pipeline identified by the `pipelineBindPoint` member of the source subpass
18. For any element of `pDependencies`, if the `dstSubpass` is not `VK_SUBPASS_EXTERNAL`, all stage flags included in the `dstStageMask` member of that dependency must be a pipeline stage supported by the pipeline identified by the `pipelineBindPoint` member of the destination subpass
19. The `srcSubpass` member of each element of `pDependencies` must be less than `subpassCount`
20. The `dstSubpass` member of each element of `pDependencies` must be less than `subpassCount`

Validations for `VkAttachmentDescription`:

1. `finalLayout` must not be `VK_IMAGE_LAYOUT_UNDEFINED` or `VK_IMAGE_LAYOUT_PREINITIALIZED`
  - **Guaranteed by the type system**
2. If format is a color format, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_STENCIL_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`
3. If format is a depth/stencil format, `initialLayout` must not be `VK_IMAGE_LAYOUT_COLOR_ATTACHMENT_OPTIMAL`
4. If format is a color format, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_STENCIL_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_STENCIL_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_STENCIL_READ_ONLY_OPTIMAL`, or `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_STENCIL_ATTACHMENT_OPTIMAL`
5. If format is a depth/stencil format, `finalLayout` must not be `VK_IMAGE_LAYOUT_COLOR_ATTACHMENT_OPTIMAL`
6. If the `separateDepthStencilLayouts` feature is not enabled, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL`, or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
7. If the `separateDepthStencilLayouts` feature is not enabled, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL`, or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
8. If format is a color format, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL`, or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
9. If format is a color format, `finalLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`, `VK_IMAGE_LAYOUT_STENCIL_ATTACHMENT_OPTIMAL`, or `VK_IMAGE_LAYOUT_STENCIL_READ_ONLY_OPTIMAL`
10. If format is a depth/stencil format which includes both depth and stencil aspects, `initialLayout` must not be `VK_IMAGE_LAYOUT_DEPTH_ATTACHMENT_OPTIMAL`, `VK_IMAGE_LAYOUT_DEPTH_READ_ONLY_OPTIMAL`,



- VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL, or  
VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL
11. If `format` is a depth/stencil format which includes both depth and stencil aspects, `finalLayout` must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL, VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL, VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL, or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL
  12. If `format` is a depth/stencil format which includes only the depth aspect, `initialLayout` must not be VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL
  13. If `format` is a depth/stencil format which includes only the depth aspect, `finalLayout` must not be VK\_IMAGE\_LAYOUT\_STENCIL\_ATTACHMENT\_OPTIMAL or VK\_IMAGE\_LAYOUT\_STENCIL\_READ\_ONLY\_OPTIMAL
  14. If `format` is a depth/stencil format which includes only the stencil aspect, `initialLayout` must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL or VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL
  15. If `format` is a depth/stencil format which includes only the stencil aspect, `finalLayout` must not be VK\_IMAGE\_LAYOUT\_DEPTH\_ATTACHMENT\_OPTIMAL or VK\_IMAGE\_LAYOUT\_DEPTH\_READ\_ONLY\_OPTIMAL

#### Validations for `VkSubpassDescription`:

1. `pipelineBindPoint` must be VK\_PIPELINE\_BIND\_POINT\_GRAPHICS
2. `colorAttachmentCount` must be less than or equal to `VkPhysicalDeviceLimits::maxColorAttachments`
  - Handled by API design
3. If the first use of an attachment in this render pass is as an input attachment, and the attachment is not also used as a color or depth/stencil attachment in the same subpass, then `loadOp` must not be VK\_ATTACHMENT\_LOAD\_OP\_CLEAR
4. If `pResolveAttachments` is not NULL, for each resolve attachment that is not VK\_ATTACHMENT\_UNUSED, the corresponding color attachment must not be VK\_ATTACHMENT\_UNUSED
5. If `pResolveAttachments` is not NULL, for each resolve attachment that is not VK\_ATTACHMENT\_UNUSED, the corresponding color attachment must not have a sample count of VK\_SAMPLE\_COUNT\_1\_BIT
6. If `pResolveAttachments` is not NULL, each resolve attachment that is not VK\_ATTACHMENT\_UNUSED must have a sample count of VK\_SAMPLE\_COUNT\_1\_BIT
7. If `pResolveAttachments` is not NULL, each resolve attachment that is not VK\_ATTACHMENT\_UNUSED must have the same `VkFormat` as its corresponding color attachment
8. All attachments in `pColorAttachments` that are not VK\_ATTACHMENT\_UNUSED must have the same sample count
9. All attachments in `pInputAttachments` that are not VK\_ATTACHMENT\_UNUSED must have formats whose features contain at least one of VK\_FORMAT\_FEATURE\_COLOR\_ATTACHMENT\_BIT or VK\_FORMAT\_FEATURE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT.
10. All attachments in `pColorAttachments` that are not VK\_ATTACHMENT\_UNUSED must have formats whose features contain VK\_FORMAT\_FEATURE\_COLOR\_ATTACHMENT\_BIT
11. All attachments in `pResolveAttachments` that are not VK\_ATTACHMENT\_UNUSED must have formats whose features contain VK\_FORMAT\_FEATURE\_COLOR\_ATTACHMENT\_BIT
12. If `pDepthStencilAttachment` is not NULL and the attachment is not VK\_ATTACHMENT\_UNUSED then it must have a format whose features contain VK\_FORMAT\_FEATURE\_DEPTH\_STENCIL\_ATTACHMENT\_BIT
13. If the `VK_AMD_mixed_attachment_samples` extension is enabled, and all attachments in `pColorAttachments` that are not VK\_ATTACHMENT\_UNUSED must have a sample count that is smaller than or equal to the sample count of `pDepthStencilAttachment` if it is not

VK\_ATTACHMENT\_UNUSED

14. If neither the VK\_AMD\_mixed\_attachment\_samples nor the VK\_NV\_framebuffer\_mixed\_samples extensions are enabled, and if pDepthStencilAttachment is not VK\_ATTACHMENT\_UNUSED and any attachments in pColorAttachments are not VK\_ATTACHMENT\_UNUSED, they must have the same sample count
15. The attachment member of each element of pPreserveAttachments must not be VK\_ATTACHMENT\_UNUSED
16. Each element of pPreserveAttachments must not also be an element of any other member of the subpass description
17. If any attachment is used by more than one VkAttachmentReference member, then each use must use the same layout
18. If flags includes VK\_SUBPASS\_DESCRIPTION\_PER\_VIEW\_POSITION\_X\_ONLY\_BIT\_NVX, it must also include VK\_SUBPASS\_DESCRIPTION\_PER\_VIEW\_ATTRIBUTES\_BIT\_NVX.
19. If the render pass is created with VK\_RENDER\_PASS\_CREATE\_TRANSFORM\_BIT\_QCOM each of the elements of pInputAttachments must be VK\_ATTACHMENT\_UNUSED.

Validations for VkSubpassDependency:

1. If the geometry shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_GEOMETRY\_SHADER\_BIT
2. If the geometry shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_GEOMETRY\_SHADER\_BIT
3. If the tessellation shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_TESSELLATION\_CONTROL\_SHADER\_BIT or VK\_PIPELINE\_STAGE\_TESSELLATION\_EVALUATION\_SHADER\_BIT
4. If the tessellation shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_TESSELLATION\_CONTROL\_SHADER\_BIT or VK\_PIPELINE\_STAGE\_TESSELLATION\_EVALUATION\_SHADER\_BIT
5. srcSubpass must be less than or equal to dstSubpass, unless one of them is VK\_SUBPASS\_EXTERNAL, to avoid cyclic dependencies and ensure a valid execution order
6. srcSubpass and dstSubpass must not both be equal to VK\_SUBPASS\_EXTERNAL
7. If srcSubpass is equal to dstSubpass and not all of the stages in srcStageMask and dstStageMask are framebuffer-space stages, the logically latest pipeline stage in srcStageMask must be logically earlier than or equal to the logically earliest pipeline stage in dstStageMask
8. Any access flag included in srcAccessMask must be supported by one of the pipeline stages in srcStageMask, as specified in the table of supported access types
9. Any access flag included in dstAccessMask must be supported by one of the pipeline stages in dstStageMask, as specified in the table of supported access types
10. If srcSubpass equals dstSubpass, and srcStageMask and dstStageMask both include a framebuffer-space stage, then dependencyFlags must include VK\_DEPENDENCY\_BY\_REGION\_BIT
11. If dependencyFlags includes VK\_DEPENDENCY\_VIEW\_LOCAL\_BIT, srcSubpass must not be equal to VK\_SUBPASS\_EXTERNAL
12. If dependencyFlags includes VK\_DEPENDENCY\_VIEW\_LOCAL\_BIT, dstSubpass must not be equal to VK\_SUBPASS\_EXTERNAL
13. If srcSubpass equals dstSubpass and that subpass has more than one bit set in the view mask, then dependencyFlags must include VK\_DEPENDENCY\_VIEW\_LOCAL\_BIT
14. If the mesh shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_MESH\_SHADER\_BIT\_NV
15. If the task shaders feature is not enabled, srcStageMask must not contain VK\_PIPELINE\_STAGE\_TASK\_SHADER\_BIT\_NV
16. If the mesh shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_MESH\_SHADER\_BIT\_NV
17. If the task shaders feature is not enabled, dstStageMask must not contain VK\_PIPELINE\_STAGE\_TASK\_SHADER\_BIT\_NV

## Framebuffer

Validations for `vkCreateFramebuffer`:

1. If `pCreateInfo→flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, and `attachmentCount` is not 0, each element of `pCreateInfo→pAttachments` must have been created on device

Validations for `VkFramebufferCreateInfo`:

1. `attachmentCount` must be equal to the attachment count specified in `renderPass`
2. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, and `attachmentCount` is not 0, `pAttachments` must be a valid pointer to an array of `attachmentCount` valid `VkImageView` handles
3. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a color attachment or resolve attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`
4. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a depth/stencil attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
5. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as a depth/stencil resolve attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
6. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` that is used as an input attachment by `renderPass` must have been created with a `usage` value including `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`
7. Each element of `pAttachments` that is used as a fragment density map attachment by `renderPass` must not have been created with a `flags` value including `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT`.
8. If `renderPass` has a fragment density map attachment and non-subsample image feature is not enabled, each element of `pAttachments` must have been created with a `flags` value including `VK_IMAGE_CREATE_SUBSAMPLED_BIT_EXT` unless that element is the fragment density map attachment.
9. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have been created with a `VkFormat` value that matches the `VkFormat` specified by the corresponding `VkAttachmentDescription` in `renderPass`
10. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have been created with a `samples` value that matches the `samples` value specified by the corresponding `VkAttachmentDescription` in `renderPass`
11. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, each element of `pAttachments` must have dimensions at least as large as the corresponding framebuffer dimension except for any element that is referenced by `fragmentDensityMapAttachment`
12. If `renderPass` was specified with non-zero view masks, each element of `pAttachments` that is not referenced by `fragmentDensityMapAttachment` must have a `layerCount` greater than the index of the most significant bit set in any of those view masks
13. If `renderPass` was specified with non-zero view masks, each element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a `layerCount` equal to 1 or greater than the index of the most significant bit set in any of those view masks
14. If `renderPass` was not specified with non-zero view masks, each element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a `layerCount` equal to 1
15. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, an element of `pAttachments` that is referenced by `fragmentDensityMapAttachment` must have a width at least as large as  $\lceil \frac{width}{maxFragmentDensityTexelSize_{width}} \rceil$
16. If `flags` does not include `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, an element of

pAttachments that is referenced by fragmentDensityMapAttachment must have a height at least as large as  $\lceil \frac{height}{maxFragmentDensityTexelSize_{height}} \rceil$

17. If flags does not include VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, each element of pAttachments must only specify a single mip level
18. If flags does not include VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, each element of pAttachments must have been created with the identity swizzle
19. width must be greater than 0.
  - Guaranteed by the type system
20. width must be less than or equal to VkPhysicalDeviceLimits::maxFramebufferWidth
21. height must be greater than 0.
  - Guaranteed by the type system
22. height must be less than or equal to VkPhysicalDeviceLimits::maxFramebufferHeight
23. layers must be greater than 0.
  - Guaranteed by the type system
24. layers must be less than or equal to VkPhysicalDeviceLimits::maxFramebufferLayers
25. If renderPass was specified with non-zero view masks, layers must be 1
26. If flags does not include VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, each element of pAttachments that is a 2D or 2D array image view taken from a 3D image must not be a depth/stencil format
27. If flags does not include VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, and attachmentCount is not 0, pAttachments must be a valid pointer to an array of attachmentCount valid VkImageView handles
28. If the imageless framebuffer feature is not enabled, flags must not include VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT
29. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the pNext chain must include a VkFramebufferAttachmentsCreateInfo structure
30. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the attachmentImageInfoCount member of a VkFramebufferAttachmentsCreateInfo structure included in the pNext chain must be equal to either zero or attachmentCount
31. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the width member of any element of the pAttachmentImageInfos member of a VkFramebufferAttachmentsCreateInfo structure included in the pNext chain must be greater than or equal to width, except for any element that is referenced by VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment in renderPass
32. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the height member of any element of the pAttachmentImageInfos member of a VkFramebufferAttachmentsCreateInfo structure included in the pNext chain must be greater than or equal to height, except for any element that is referenced by VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment in renderPass
33. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the width member of any element of the pAttachmentImageInfos member of a VkFramebufferAttachmentsCreateInfo structure included in the pNext chain that is referenced by VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment in renderPass must be greater than or equal to  $\lceil \frac{width}{maxFragmentDensityTexelSize_{width}} \rceil$
34. If flags includes VK\_FRAMEBUFFER\_CREATE\_IMAGELESS\_BIT, the height member of any element of the pAttachmentImageInfos member of a VkFramebufferAttachmentsCreateInfo structure included in the pNext chain that is referenced by VkRenderPassFragmentDensityMapCreateInfoEXT::fragmentDensityMapAttachment in

`renderPass` must be greater than or equal to  $\lceil \frac{height}{maxFragmentDensityTexelSize_{height}} \rceil$

35. If multiview is enabled for `renderPass`, and `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `layerCount` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than the maximum bit index set in the view mask in the subpasses in which it is used in `renderPass`
36. If multiview is not enabled for `renderPass`, and `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `layerCount` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be greater than or equal to `layers`
37. If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a color attachment or resolve attachment by `renderPass` must include `VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT`
38. If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a depth/stencil attachment by `renderPass` must include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
39. If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as a depth/stencil resolve attachment by `renderPass` must include `VK_IMAGE_USAGE_DEPTH_STENCIL_ATTACHMENT_BIT`
40. If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, the `usage` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain that refers to an attachment used as an input attachment by `renderPass` must include `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT`
41. If `flags` includes `VK_FRAMEBUFFER_CREATE_IMAGELESS_BIT`, at least one element of the `pViewFormats` member of any element of the `pAttachmentImageInfos` member of a `VkFramebufferAttachmentsCreateInfo` structure included in the `pNext` chain must be equal to the corresponding value of `VkAttachmentDescription::format` used to create `renderPass`

## Pipeline

Validations for `VkPipelineLayoutCreateInfo`:

1. `setLayoutCount` must be less than or equal to `VkPhysicalDeviceLimits::maxBoundDescriptorSets`
2. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_SAMPLER` and `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorSamplers`
3. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` and `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorUniformBuffers`



4. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` and `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorStorageBuffers`
5. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, and `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorSampledImages`
6. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, and `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorStorageImages`
7. The total number of descriptors in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceLimits::maxPerStageDescriptorInputAttachments`
8. The total number of bindings in descriptor set layouts created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxPerStageDescriptorInlineUniformBlocks`
9. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_SAMPLER` and `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindSamplers`
10. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` and `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindUniformBuffers`
11. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` and `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindStorageBuffers`
12. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, and `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindSampledImages`
13. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, and `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindStorageImages`
14. The total number of descriptors with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` accessible to any given shader stage across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorInputAttachments`

- VkPhysicalDeviceDescriptorIndexingProperties::maxPerStageDescriptorUpdateAfterBindInputAttachments
15. The total number of bindings with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INLINE\_UNIFORM\_BLOCK\_EXT accessible to any given shader stage across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxPerStageDescriptorUpdateAfterBindInlineUniformBlocks
  16. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_SAMPLER and VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetSamplers
  17. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_UNIFORM\_BUFFER accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetUniformBuffers
  18. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_UNIFORM\_BUFFER\_DYNAMIC accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetUniformBuffersDynamic
  19. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_BUFFER accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetStorageBuffers
  20. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_BUFFER\_DYNAMIC accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetStorageBuffersDynamic
  21. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER, VK\_DESCRIPTOR\_TYPE\_SAMPLED\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_UNIFORM\_TEXEL\_BUFFER accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetSampledImages
  22. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_STORAGE\_IMAGE, and VK\_DESCRIPTOR\_TYPE\_STORAGE\_TEXEL\_BUFFER accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetStorageImages
  23. The total number of descriptors in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INPUT\_ATTACHMENT accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceLimits::maxDescriptorSetInputAttachments
  24. The total number of bindings in descriptor set layouts created without the VK\_DESCRIPTOR\_SET\_LAYOUT\_CREATE\_UPDATE\_AFTER\_BIND\_POOL\_BIT bit set with a descriptorType of VK\_DESCRIPTOR\_TYPE\_INLINE\_UNIFORM\_BLOCK\_EXT accessible across all shader stages and across all elements of pSetLayouts must be less than or equal to  
VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxDescriptorSetInlineUniformBlocks
  25. The total number of descriptors of the type VK\_DESCRIPTOR\_TYPE\_SAMPLER and VK\_DESCRIPTOR\_TYPE\_COMBINED\_IMAGE\_SAMPLER accessible across all shader stages and

- across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindSamplers`
26. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindUniformBuffer`
  27. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindUniformBuffer`
  28. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageBuffer`
  29. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageBuffer`
  30. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, and `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindSampledImages`
  31. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, and `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindStorageImages`
  32. The total number of descriptors of the type `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceDescriptorIndexingProperties::maxDescriptorSetUpdateAfterBindInputAttachm`
  33. The total number of bindings with a `descriptorType` of `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceInlineUniformBlockPropertiesEXT::maxDescriptorSetUpdateAfterBindInlineUni`
  34. Any two elements of `pPushConstantRanges` must not include the same stage in `stageFlags`
  35. `pSetLayouts` must not contain more than one descriptor set layout that was created with `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR` set
  36. The total number of bindings with a `descriptorType` of `VK_DESCRIPTOR_TYPE_ACCELERATION_STRUCTURE_KHR` accessible across all shader stages and across all elements of `pSetLayouts` must be less than or equal to `VkPhysicalDeviceRayTracingPropertiesKHR::maxDescriptorSetAccelerationStructures`

#### Validations for `VkPushConstantRange`:

1. offset must be less than `VkPhysicalDeviceLimits::maxPushConstantsSize`
2. offset must be a multiple of 4
  - [Handled by API design](#)
3. size must be greater than 0
  - [Guaranteed by the type system](#)
4. size must be a multiple of 4
  - [Handled by API design](#)
5. size must be less than or equal to `VkPhysicalDeviceLimits::maxPushConstantsSize` minus offset



## Shader

Validations for `VkShaderModuleCreateInfo`:

1. `codeSize` must be greater than 0
2. If `pCode` is a pointer to SPIR-V code, `codeSize` must be a multiple of 4
  - [Guaranteed by the type system](#)
3. `pCode` must point to either valid SPIR-V code, formatted and packed as described by the Khronos SPIR-V Specification or valid GLSL code which must be written to the `GL_KHR_vulkan_glsl` extension specification
4. If `pCode` is a pointer to SPIR-V code, that code must adhere to the validation rules described by the Validation Rules within a Module section of the SPIR-V Environment appendix
5. If `pCode` is a pointer to GLSL code, it must be valid GLSL code written to the `GL_KHR_vulkan_glsl` GLSL extension specification
6. `pCode` must declare the `Shader` capability for SPIR-V code
7. `pCode` must not declare any capability that is not supported by the API, as described by the `Capabilities` section of the SPIR-V Environment appendix
8. If `pCode` declares any of the capabilities listed as optional in the SPIR-V Environment appendix, the corresponding feature(s) must be enabled.

## Usage validations

Validations of correct unsage in other functions as dictated by the Vulkan specification.

## Queue

Validations for `vkGetDeviceQueue`:

1. `queueFamilyIndex` must be one of the queue family indices specified when `device` was created, via the `VkDeviceQueueCreateInfo` structure
  - [Handled by API design](#)
2. `queueIndex` must be less than the number of queues created for the specified queue family index when `device` was created, via the `queueCount` member of the `VkDeviceQueueCreateInfo` structure
  - [Handled by API design](#)
3. `VkDeviceQueueCreateInfo::flags` must have been set to zero when `device` was created
  - [Handled by API design](#)

Validations for `vkQueueSubmit`:

1. If `fence` is not `VK_NULL_HANDLE`, `fence` must be unsignaled
2. If `fence` is not `VK_NULL_HANDLE`, `fence` must not be associated with any other queue command that has not yet completed execution on that queue
3. Any calls to `vkCmdSetEvent`, `vkCmdResetEvent` or `vkCmdWaitEvents` that have been recorded into any of the command buffer elements of the `pCommandBuffers` member of any element of `pSubmits`, must not reference any `VkEvent` that is referenced by any of those commands in a command buffer that has been submitted to another queue and is still in the *pending state*
4. Any stage flag included in any element of the `pWaitDstStageMask` member of any element of `pSubmits` must be a pipeline stage supported by one of the capabilities of `queue`, as specified in the table of supported pipeline stages
5. Each element of the `pSignalSemaphores` member of any element of `pSubmits` must be unsignaled when the semaphore signal operation it defines is executed on the device
6. When a semaphore wait operation referring to a binary semaphore defined by any element of the

`pWaitSemaphores` member of any element of `pSubmits` executes on queue, there must be no other queues waiting on the same semaphore

7. All elements of the `pWaitSemaphores` member of all elements of `pSubmits` created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_BINARY` must reference a semaphore signal operation that has been submitted for execution and any semaphore signal operations on which it depends (if any) must have also been submitted for execution
8. Each element of the `pCommandBuffers` member of each element of `pSubmits` must be in the pending or executable state
9. If any element of the `pCommandBuffers` member of any element of `pSubmits` was not recorded with the `VK_COMMAND_BUFFER_USAGE_SIMULTANEOUS_USE_BIT`, it must not be in the pending state
10. Any secondary command buffers recorded into any element of the `pCommandBuffers` member of any element of `pSubmits` must be in the pending or executable state
11. If any secondary command buffers recorded into any element of the `pCommandBuffers` member of any element of `pSubmits` was not recorded with the `VK_COMMAND_BUFFER_USAGE_SIMULTANEOUS_USE_BIT`, it must not be in the pending state
12. Each element of the `pCommandBuffers` member of each element of `pSubmits` must have been allocated from a `VkCommandPool` that was created for the same queue family queue belongs to
  - Returns error
13. If any element of `pSubmits`→`pCommandBuffers` includes a Queue Family Transfer Acquire Operation, there must exist a previously submitted Queue Family Transfer Release Operation on a queue in the queue family identified by the acquire operation, with parameters matching the acquire operation as defined in the definition of such acquire operations, and which happens-before the acquire operation
14. If a command recorded into any element of `pCommandBuffers` was a `vkCmdBeginQuery` whose `queryPool` was created with a `queryType` of `VK_QUERY_TYPE_PERFORMANCE_QUERY_KHR`, the profiling lock must have been held continuously on the `VkDevice` that queue was retrieved from, throughout recording of those command buffers
15. Any resource created with `VK_SHARING_MODE_EXCLUSIVE` that is read by an operation specified by `pSubmits` must not be owned by any queue family other than the one which queue belongs to, at the time it is executed

#### Validations for `VkSubmitInfo`:

1. Each element of `pCommandBuffers` must not have been allocated with `VK_COMMAND_BUFFER_LEVEL_SECONDARY`
2. If the geometry shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_GEOMETRY_SHADER_BIT`
3. If the tessellation shaders feature is not enabled, each element of `pWaitDstStageMask` must not contain `VK_PIPELINE_STAGE_TESSELLATION_CONTROL_SHADER_BIT` or `VK_PIPELINE_STAGE_TESSELLATION_EVALUATION_SHADER_BIT`
4. Each element of `pWaitDstStageMask` must not include `VK_PIPELINE_STAGE_HOST_BIT`.
5. If any element of `pWaitSemaphores` or `pSignalSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then the `pNext` chain must include a `VkTimelineSemaphoreSubmitInfo` structure
6. If the `pNext` chain of this structure includes a `VkTimelineSemaphoreSubmitInfo` structure and any element of `pWaitSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then its `waitSemaphoreValueCount` member must equal `waitSemaphoreCount`
7. If the `pNext` chain of this structure includes a `VkTimelineSemaphoreSubmitInfo` structure and any element of `pSignalSemaphores` was created with a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_TIMELINE`, then its `signalSemaphoreValueCount` member must equal `signalSemaphoreCount`
8. For each element of `pSignalSemaphores` created with a `VkSemaphoreType` of

- VK\_SEMAPHORE\_TYPE\_TIMELINE the corresponding element of VkTimelineSemaphoreSubmitInfo::pSignalSemaphoreValues must have a value greater than the current value of the semaphore when the semaphore signal operation is executed
9. For each element of pWaitSemaphores created with a VkSemaphoreType of VK\_SEMAPHORE\_TYPE\_TIMELINE the corresponding element of VkTimelineSemaphoreSubmitInfo::pWaitSemaphoreValues must have a value which does not differ from the current value of the semaphore or the value of any outstanding semaphore wait or signal operation on that semaphore by more than maxTimelineSemaphoreValueDifference.
  10. For each element of pSignalSemaphores created with a VkSemaphoreType of VK\_SEMAPHORE\_TYPE\_TIMELINE the corresponding element of VkTimelineSemaphoreSubmitInfo::pSignalSemaphoreValues must have a value which does not differ from the current value of the semaphore or the value of any outstanding semaphore wait or signal operation on that semaphore by more than maxTimelineSemaphoreValueDifference.
  11. If the mesh shaders feature is not enabled, each element of pWaitDstStageMask must not contain VK\_PIPELINE\_STAGE\_MESH\_SHADER\_BIT\_NV
  12. If the task shaders feature is not enabled, each element of pWaitDstStageMask must not contain VK\_PIPELINE\_STAGE\_TASK\_SHADER\_BIT\_NV

## Swapchain

Validations for vkAcquireNextImageKHR:

1. swapchain must not be in the retired state
2. If semaphore is not VK\_NULL\_HANDLE it must be unsignaled
3. If semaphore is not VK\_NULL\_HANDLE it must not have any uncompleted signal or wait operations pending
4. If fence is not VK\_NULL\_HANDLE it must be unsignaled and must not be associated with any other queue command that has not yet completed execution on that queue
5. semaphore and fence must not both be equal to VK\_NULL\_HANDLE
  - [Handled by API design](#)
6. If the number of currently acquired images is greater than the difference between the number of images in swapchain and the value of VkSurfaceCapabilitiesKHR::minImageCount as returned by a call to vkGetPhysicalDeviceSurfaceCapabilities2KHR with the surface used to create swapchain, timeout must not be UINT64\_MAX
7. semaphore must have a VkSemaphoreType of VK\_SEMAPHORE\_TYPE\_BINARY
  - [Guaranteed by the type system](#)

Validations for vkQueuePresentKHR:

1. Each element of pSwapchains member of pPresentInfo must be a swapchain that is created for a surface for which presentation is supported from queue as determined using a call to vkGetPhysicalDeviceSurfaceSupportKHR
2. If more than one member of pSwapchains was created from a display surface, all display surfaces referenced that refer to the same display must use the same display mode
3. When a semaphore wait operation referring to a binary semaphore defined by the elements of the pWaitSemaphores member of pPresentInfo executes on queue, there must be no other queues waiting on the same semaphore.
4. All elements of the pWaitSemaphores member of pPresentInfo must be semaphores that are signaled, or have semaphore signal operations previously submitted for execution.
5. All elements of the pWaitSemaphores member of pPresentInfo must be created with a VkSemaphoreType of VK\_SEMAPHORE\_TYPE\_BINARY.
  - [Handled by API design](#)

6. All elements of the `pWaitSemaphores` member of `pPresentInfo` must reference a semaphore signal operation that has been submitted for execution and any semaphore signal operations on which it depends (if any) must have also been submitted for execution.

Validations for `VkPresentInfoKHR`:

1. Each element of `pImageIndices` must be the index of a presentable image acquired from the swapchain specified by the corresponding element of the `pSwapchains` array, and the presented image subresource must be in the `VK_IMAGE_LAYOUT_PRESENT_SRC_KHR` or `VK_IMAGE_LAYOUT_SHARED_PRESENT_KHR` layout at the time the operation is executed on a `VkDevice`
  - [Guaranteed by the type system](#)
2. All elements of the `pWaitSemaphores` must have a `VkSemaphoreType` of `VK_SEMAPHORE_TYPE_BINARY`

## Fence

Validations for `vkResetFences`:

1. Each element of `pFences` must not be currently associated with any queue command that has not yet completed execution on that queue

## Image

Validations for `vkBindImageMemory`:

1. `image` must not have been created with the `VK_IMAGE_CREATE_DISJOINT_BIT` set.
2. `image` must not already be backed by a memory object
  - [Handled by API design](#)
3. `image` must not have been created with any sparse memory binding flags
4. `memoryOffset` must be less than the size of memory
  - [Handled by API design](#)
5. `memory` must have been allocated using one of the memory types allowed in the `memoryTypeBits` member of the `VkMemoryRequirements` structure returned from a call to `vkGetImageMemoryRequirements` with `image`
  - [Handled by API design](#)
6. `memoryOffset` must be an integer multiple of the `alignment` member of the `VkMemoryRequirements` structure returned from a call to `vkGetImageMemoryRequirements` with `image`
  - [Handled by API design](#)
7. The difference of the size of `memory` and `memoryOffset` must be greater than or equal to the `size` member of the `VkMemoryRequirements` structure returned from a call to `vkGetImageMemoryRequirements` with the same `image`
  - [Handled by API design](#)
8. If `image` requires a dedicated allocation (as reported by `vkGetImageMemoryRequirements2` in `VkMemoryDedicatedRequirements::requiresDedicatedAllocation` for `image`), `memory` must have been created with `VkMemoryDedicatedAllocateInfo::image` equal to `image`
9. If the dedicated allocation image aliasing feature is not enabled, and the `VkMemoryAllocateInfo` provided when `memory` was allocated included a `VkMemoryDedicatedAllocateInfo` structure in its `pNext` chain, and `VkMemoryDedicatedAllocateInfo::image` was not `VK_NULL_HANDLE`, then `image` must equal

- `VkMemoryDedicatedAllocateInfo::image` and `memoryOffset` must be zero.
10. If the dedicated allocation image aliasing feature is enabled, and the `VkMemoryAllocateInfo` provided when memory was allocated included a `VkMemoryDedicatedAllocateInfo` structure in its `pNext` chain, and `VkMemoryDedicatedAllocateInfo::image` was not `VK_NULL_HANDLE`, then `memoryOffset` must be zero, and `image` must be either equal to `VkMemoryDedicatedAllocateInfo::image` or an image that was created using the same parameters in `VkImageCreateInfo`, with the exception that `extent` and `arrayLayers` may differ subject to the following restrictions: every dimension in the `extent` parameter of the image being bound must be equal to or smaller than the original image for which the allocation was created; and the `arrayLayers` parameter of the image being bound must be equal to or smaller than the original image for which the allocation was created.
  11. If image was created with the `VK_IMAGE_CREATE_PROTECTED_BIT` bit set, the image must be bound to a memory object allocated with a memory type that reports `VK_MEMORY_PROPERTY_PROTECTED_BIT`
  12. If image was created with the `VK_IMAGE_CREATE_PROTECTED_BIT` bit not set, the image must not be bound to a memory object created with a memory type that reports `VK_MEMORY_PROPERTY_PROTECTED_BIT`
  13. If `image` was created with `VkDedicatedAllocationImageCreateInfoNV::dedicatedAllocation` equal to `VK_TRUE`, memory must have been created with `VkDedicatedAllocationMemoryAllocateInfoNV::image` equal to an image handle created with identical creation parameters to `image` and `memoryOffset` must be zero
  14. If the value of `VkExportMemoryAllocateInfo::handleTypes` used to allocate memory is not 0, it must include at least one of the handles set in `VkExternalMemoryImageCreateInfo::handleTypes` when `image` was created
  15. If memory was created by a memory import operation, the external handle type of the imported memory must also have been set in `VkExternalMemoryImageCreateInfo::handleTypes` when `image` was created

## Buffer

Validations for `vkBindBufferMemory`:

1. `buffer` must not already be backed by a memory object
  - [Handled by API design](#)
2. `buffer` must not have been created with any sparse memory binding flags
3. `memoryOffset` must be less than the size of memory
  - [Handled by API design](#)
4. memory must have been allocated using one of the memory types allowed in the `memoryTypeBits` member of the `VkMemoryRequirements` structure returned from a call to `vkGetBufferMemoryRequirements` with `buffer`
  - [Handled by API design](#)
5. `memoryOffset` must be an integer multiple of the `alignment` member of the `VkMemoryRequirements` structure returned from a call to `vkGetBufferMemoryRequirements` with `buffer`
  - [Handled by API design](#)
6. The `size` member of the `VkMemoryRequirements` structure returned from a call to `vkGetBufferMemoryRequirements` with `buffer` must be less than or equal to the size of memory minus `memoryOffset`
  - [Handled by API design](#)
7. If `buffer` requires a dedicated allocation (as reported by `vkGetBufferMemoryRequirements2` in `VkMemoryDedicatedRequirements::requiresDedicatedAllocation` for `buffer`), memory must have been created with `VkMemoryDedicatedAllocateInfo::buffer` equal to `buffer`

8. If the `VkMemoryAllocateInfo` provided when memory was allocated included a `VkMemoryDedicatedAllocateInfo` structure in its `pNext` chain, and `VkMemoryDedicatedAllocateInfo::buffer` was not `VK_NULL_HANDLE`, then `buffer` must equal `VkMemoryDedicatedAllocateInfo::buffer`, and `memoryOffset` must be zero.
9. If `buffer` was created with the `VK_BUFFER_CREATE_PROTECTED_BIT` bit set, the buffer must be bound to a memory object allocated with a memory type that reports `VK_MEMORY_PROPERTY_PROTECTED_BIT`
10. If `buffer` was created with the `VK_BUFFER_CREATE_PROTECTED_BIT` bit not set, the buffer must not be bound to a memory object created with a memory type that reports `VK_MEMORY_PROPERTY_PROTECTED_BIT`
11. If `buffer` was created with `VkDedicatedAllocationBufferCreateInfoNV::dedicatedAllocation` equal to `VK_TRUE`, memory must have been created with `VkDedicatedAllocationMemoryAllocateInfoNV::buffer` equal to a buffer handle created with identical creation parameters to `buffer` and `memoryOffset` must be zero
12. If the value of `VkExportMemoryAllocateInfo::handleTypes` used to allocate memory is not 0, it must include at least one of the handles set in `VkExternalMemoryBufferCreateInfo::handleTypes` when `buffer` was created
13. If memory was created by a memory import operation, the external handle type of the imported memory must also have been set in `VkExternalMemoryBufferCreateInfo::handleTypes` when `buffer` was created
14. If the `VkPhysicalDeviceBufferDeviceAddressFeatures::bufferDeviceAddress` feature is enabled and `buffer` was created with the `VK_BUFFER_USAGE_SHADER_DEVICE_ADDRESS_BIT` bit set, memory must have been allocated with the `VK_MEMORY_ALLOCATE_DEVICE_ADDRESS_BIT` bit set

#### Validations for `vkMapMemory`:

1. memory must not be currently host mapped
  - [Handled by API design](#)
2. `offset` must be less than the size of memory
3. If `size` is not equal to `VK_WHOLE_SIZE`, `size` must be greater than 0
  - [Guaranteed by the type system](#)
4. If `size` is not equal to `VK_WHOLE_SIZE`, `size` must be less than or equal to the size of the memory minus `offset`
5. memory must have been created with a memory type that reports `VK_MEMORY_PROPERTY_HOST_VISIBLE_BIT`
6. memory must not have been allocated with multiple instances.

#### Validations for `VkMappedMemoryRange`:

1. memory must be currently host mapped
  - [Handled by API design](#)
2. If `size` is not equal to `VK_WHOLE_SIZE`, `offset` and `size` must specify a range contained within the currently mapped range of memory
  - [Handled by API design](#)
3. If `size` is equal to `VK_WHOLE_SIZE`, `offset` must be within the currently mapped range of memory
  - [Handled by API design](#)
4. If `size` is equal to `VK_WHOLE_SIZE`, the end of the current mapping of memory must be a multiple of `VkPhysicalDeviceLimits::nonCoherentAtomSize` bytes from the beginning of the memory object.



5. `offset` must be a multiple of `VkPhysicalDeviceLimits::nonCoherentAtomSize`
6. If `size` is not equal to `VK_WHOLE_SIZE`, `size` must either be a multiple of `VkPhysicalDeviceLimits::nonCoherentAtomSize`, or `offset` plus `size` must equal the size of memory.

## Descriptor

Validations for `VkDescriptorSetAllocateInfo`:

1. Each element of `pSetLayouts` must not have been created with `VK_DESCRIPTOR_SET_LAYOUT_CREATE_PUSH_DESCRIPTOR_BIT_KHR` set
2. If any element of `pSetLayouts` was created with the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` bit set, `descriptorPool` must have been created with the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set

Validations for `VkDescriptorBufferInfo`:

1. `offset` must be less than the size of buffer
2. If `range` is not equal to `VK_WHOLE_SIZE`, `range` must be greater than 0
  - [Guaranteed by the type system](#)
3. If `range` is not equal to `VK_WHOLE_SIZE`, `range` must be less than or equal to the size of buffer minus `offset`

Validations for `VkDescriptorImageInfo`:

1. `imageView` must not be 2D or 2D array image view created from a 3D image
2. If `imageView` is created from a depth/stencil image, the `aspectMask` used to create the `imageView` must include either `VK_IMAGE_ASPECT_DEPTH_BIT` or `VK_IMAGE_ASPECT_STENCIL_BIT` but not both.
3. `imageLayout` must match the actual `VkImageLayout` of each subresource accessible from `imageView` at the time this descriptor is accessed as defined by the image layout matching rules
4. If `sampler` is used and the `VkFormat` of the image is a multi-planar format, the image must have been created with `VK_IMAGE_CREATE_MUTABLE_FORMAT_BIT`, and the `aspectMask` of the `imageView` must be `VK_IMAGE_ASPECT_PLANE_0_BIT`, `VK_IMAGE_ASPECT_PLANE_1_BIT` or (for three-plane formats only) `VK_IMAGE_ASPECT_PLANE_2_BIT`

Validations for `VkWriteDescriptorSetInlineUniformBlockEXT`:

1. `dataSize` must be an integer multiple of 4
  - [Returns error](#)

Validations for `VkWriteDescriptorSet`:

1. `dstBinding` must be less than or equal to the maximum value of `binding` of all `VkDescriptorSetLayoutBinding` structures specified when `dstSet`'s descriptor set layout was created
2. `dstBinding` must be a binding with a non-zero `descriptorCount`
3. All consecutive bindings updated via a single `VkWriteDescriptorSet` structure, except those with a `descriptorCount` of zero, must have identical `descriptorType` and `stageFlags`.
4. All consecutive bindings updated via a single `VkWriteDescriptorSet` structure, except those

with a `descriptorCount` of zero, must all either use immutable samplers or must all not use immutable samplers.

5. `descriptorType` must match the type of `dstBinding` within `dstSet`

6. `dstSet` must be a valid `VkDescriptorSet` handle

- [Handled by API design](#)

7. The sum of `dstArrayElement` and `descriptorCount` must be less than or equal to the number of array elements in the descriptor set binding specified by `dstBinding`, and all applicable consecutive bindings, as described by consecutive binding updates

8. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, `dstArrayElement` must be an integer multiple of 4

9. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, `descriptorCount` must be an integer multiple of 4

- [Returns error](#)

10. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLER`, `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, or `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT`, `pImageInfo` must be a valid pointer to an array of `descriptorCount` valid `VkDescriptorImageInfo` structures

- [Handled by API design](#)

11. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER` or `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER`, `pTexelBufferView` must be a valid pointer to an array of `descriptorCount` valid `VkBufferView` handles

- [Handled by API design](#)

12. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER`, `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER`, `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC`, or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`, `pBufferInfo` must be a valid pointer to an array of `descriptorCount` valid `VkDescriptorBufferInfo` structures

- [Handled by API design](#)

13. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLER` or `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, and `dstSet` was not allocated with a layout that included immutable samplers for `dstBinding` with `descriptorType`, the `sampler` member of each element of `pImageInfo` must be a valid `VkSampler` object

14. If `descriptorType` is `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, or `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT`, the `imageView` and `imageLayout` members of each element of `pImageInfo` must be a valid `VkImageView` and `VkImageLayout`, respectively

- [Handled by API design](#)

15. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, the `pNext` chain must include a `VkWriteDescriptorSetInlineUniformBlockEXT` structure whose `dataSize` member equals `descriptorCount`

- [Handled by API design](#)

16. If `descriptorType` is `VK_DESCRIPTOR_TYPE_ACCELERATION_STRUCTURE_KHR`, the `pNext` chain must include a `VkWriteDescriptorSetAccelerationStructureKHR` structure whose `accelerationStructureCount` member equals `descriptorCount`

17. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE`, then the `imageView` member of each `pImageInfo` element must have been created without a `VkSamplerYcbcrConversionInfo` structure in its `pNext` chain

18. If `descriptorType` is `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, and if any element of `pImageInfo` has a `imageView` member that was created with a `VkSamplerYcbcrConversionInfo` structure in its `pNext` chain, then `dstSet` must have been allocated with a layout that included immutable samplers for `dstBinding`, and the corresponding immutable sampler must have been created with an *identically defined* `VkSamplerYcbcrConversionInfo` object



19. If `descriptorType` is `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, and `dstSet` was allocated with a layout that included immutable samplers for `dstBinding`, then the `imageView` member of each element of `pImageInfo` which corresponds to an immutable sampler that enables sampler Y<sub>0</sub> CbCr conversion must have been created with a `VkSamplerYcbcrConversionInfo` structure in its `pNext` chain with an *identically defined* `VkSamplerYcbcrConversionInfo` to the corresponding immutable sampler
20. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, for each descriptor that will be accessed via load or store operations the `imageLayout` member for corresponding elements of `pImageInfo` must be `VK_IMAGE_LAYOUT_GENERAL`
21. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` or `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC`, the `offset` member of each element of `pBufferInfo` must be a multiple of `VkPhysicalDeviceLimits::minUniformBufferOffsetAlignment`
22. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`, the `offset` member of each element of `pBufferInfo` must be a multiple of `VkPhysicalDeviceLimits::minStorageBufferOffsetAlignment`
23. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER`, `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC`, `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER`, or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`, and the `buffer` member of any element of `pBufferInfo` is the handle of a non-sparse buffer, then that buffer must be bound completely and contiguously to a single `VkDeviceMemory` object
24. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` or `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC`, the `buffer` member of each element of `pBufferInfo` must have been created with `VK_BUFFER_USAGE_UNIFORM_BUFFER_BIT` set
25. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`, the `buffer` member of each element of `pBufferInfo` must have been created with `VK_BUFFER_USAGE_STORAGE_BUFFER_BIT` set
26. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER` or `VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER_DYNAMIC`, the `range` member of each element of `pBufferInfo`, or the effective range if `range` is `VK_WHOLE_SIZE`, must be less than or equal to `VkPhysicalDeviceLimits::maxUniformBufferRange`
27. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER` or `VK_DESCRIPTOR_TYPE_STORAGE_BUFFER_DYNAMIC`, the `range` member of each element of `pBufferInfo`, or the effective range if `range` is `VK_WHOLE_SIZE`, must be less than or equal to `VkPhysicalDeviceLimits::maxStorageBufferRange`
28. If `descriptorType` is `VK_DESCRIPTOR_TYPE_UNIFORM_TEXEL_BUFFER`, the `VkBuffer` that each element of `pTexelBufferView` was created from must have been created with `VK_BUFFER_USAGE_UNIFORM_TEXEL_BUFFER_BIT` set
29. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_TEXEL_BUFFER`, the `VkBuffer` that each element of `pTexelBufferView` was created from must have been created with `VK_BUFFER_USAGE_STORAGE_TEXEL_BUFFER_BIT` set
30. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE` or `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT`, the `imageView` member of each element of `pImageInfo` must have been created with the identity swizzle
31. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE` or `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, the `imageView` member of each element of `pImageInfo` must have been created with `VK_IMAGE_USAGE_SAMPLED_BIT` set
32. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLED_IMAGE` or `VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER`, the `imageLayout` member of each element of `pImageInfo` must be a member of the list given in Sampled Image or Combined Image Sampler, corresponding to its type
33. If `descriptorType` is `VK_DESCRIPTOR_TYPE_INPUT_ATTACHMENT`, the `imageView` member of each element of `pImageInfo` must have been created with `VK_IMAGE_USAGE_INPUT_ATTACHMENT_BIT` set

34. If `descriptorType` is `VK_DESCRIPTOR_TYPE_STORAGE_IMAGE`, the `imageView` member of each element of `pImageInfo` must have been created with `VK_IMAGE_USAGE_STORAGE_BIT` set
35. All consecutive bindings updated via a single `VkWriteDescriptorSet` structure, except those with a `descriptorCount` of zero, must have identical `VkDescriptorBindingFlagBits`.
36. If `descriptorType` is `VK_DESCRIPTOR_TYPE_SAMPLER`, then `dstSet` must not have been allocated with a layout that included immutable samplers for `dstBinding`

#### Validations for `VkCopyDescriptorSet`:

1. `srcBinding` must be a valid binding within `srcSet`
2. The sum of `srcArrayElement` and `descriptorCount` must be less than or equal to the number of array elements in the descriptor set binding specified by `srcBinding`, and all applicable consecutive bindings, as described by consecutive binding updates
3. `dstBinding` must be a valid binding within `dstSet`
4. The sum of `dstArrayElement` and `descriptorCount` must be less than or equal to the number of array elements in the descriptor set binding specified by `dstBinding`, and all applicable consecutive bindings, as described by consecutive binding updates
5. The type of `dstBinding` within `dstSet` must be equal to the type of `srcBinding` within `srcSet`
6. If `srcSet` is equal to `dstSet`, then the source and destination ranges of descriptors must not overlap, where the ranges may include array elements from consecutive bindings as described by consecutive binding updates
7. If the descriptor type of the descriptor set binding specified by `srcBinding` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, `srcArrayElement` must be an integer multiple of 4
8. If the descriptor type of the descriptor set binding specified by `dstBinding` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, `dstArrayElement` must be an integer multiple of 4
9. If the descriptor type of the descriptor set binding specified by either `srcBinding` or `dstBinding` is `VK_DESCRIPTOR_TYPE_INLINE_UNIFORM_BLOCK_EXT`, `descriptorCount` must be an integer multiple of 4
10. If `srcSet`'s layout was created with the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` flag set, then `dstSet`'s layout must also have been created with the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` flag set
11. If `srcSet`'s layout was created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` flag set, then `dstSet`'s layout must also have been created without the `VK_DESCRIPTOR_SET_LAYOUT_CREATE_UPDATE_AFTER_BIND_POOL_BIT` flag set
12. If the descriptor pool from which `srcSet` was allocated was created with the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set, then the descriptor pool from which `dstSet` was allocated must also have been created with the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set
13. If the descriptor pool from which `srcSet` was allocated was created without the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set, then the descriptor pool from which `dstSet` was allocated must also have been created without the `VK_DESCRIPTOR_POOL_CREATE_UPDATE_AFTER_BIND_BIT` flag set
14. If the descriptor type of the descriptor set binding specified by `dstBinding` is `VK_DESCRIPTOR_TYPE_SAMPLER`, then `dstSet` must not have been allocated with a layout that included immutable samplers for `dstBinding`

#### Validations for `vkUpdateDescriptorSets`:

1. Descriptor bindings updated by this command which were created without the `VK_DESCRIPTOR_BINDING_UPDATE_AFTER_BIND_BIT` or

VK\_DESCRIPTOR\_BINDING\_UPDATE\_UNUSED\_WHILE\_PENDING\_BIT bits set must not be used by any command that was recorded to a command buffer which is in the pending state.

## Shader

Validations for `VkVertexInputBindingDescription`:

1. `binding` must be less than `VkPhysicalDeviceLimits::maxVertexInputBindings`
2. `stride` must be less than or equal to `VkPhysicalDeviceLimits::maxVertexInputBindingStride`

Validations for `VkVertexInputAttributeDescription`:

1. `location` must be less than `VkPhysicalDeviceLimits::maxVertexInputAttributes`
2. `binding` must be less than `VkPhysicalDeviceLimits::maxVertexInputBindings`
3. `offset` must be less than or equal to `VkPhysicalDeviceLimits::maxVertexInputAttributeOffset`
4. `format` must be allowed as a vertex buffer format, as specified by the `VK_FORMAT_FEATURE_VERTEX_BUFFER_BIT` flag in `VkFormatProperties::bufferFeatures` returned by `vkGetPhysicalDeviceFormatProperties`

## Statistics

Category	Statically solved	Dynamically solved	Left to user	Total
Implicit	317	27	3	347
Creation	91	0	314	405
Usage	29	3	122	154
<b>Total</b>	437	30	439	906