Quake III Arena Shader Manual Revision #12

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Anywhere you see [Quake III Arena], you may also reference [Quake Live].
Anywhere you see [Q3Radiant], you may also reference [GtkRadiant], or [NetRadiant].

1. Preface: Making Your Own Shaders

The manual for the [Q3Radiant] editor program contains a section called "Creating New Assets" that has the necessary information for setting up the files to create your own custom [Quake III Arena] shaders.

It is recommended that you study the scripts in this document, as well as the individual shader scripts.

Pay careful attention to (syntax/punctuation), as this is where you will most likely make mistakes.

However, [Q3ASE] makes this easier.

2. Introduction

The graphic engine for [Quake III Arena] has taken a step forward, by putting much more [direct control] over the [surface qualities] of [textures] into the hands of (designers/artists).

In writing this manual, we have tried to define (concepts/tools) that are used to modify textures in a way that is hoped, will be graspable by users who already have basic knowledge of computer graphics… but are not necessarily computer programmers.

It is not a tutorial, nor was it intended to be one.

At least the original version wasn't.

2.1 What is a Shader?

[Shaders] are [short text scripts] that [define the properties of a surface], as it (appears/functions) in the game world, or a compatible editing tool (<such as Q3ASE>).

By convention, the [documents] that contain these [scripts] usually have the [same name as the texture set] which [contains the textures being modified] (e.g; base, hell, castle, etc,).

Several specific script documents have also been created to handle special cases… like [liquids], [skies], and [special effects].

For [Quake III Arena], Shader scripts are located in (quake3/baseq3/scripts).

A [Quake III Arena] (*.shader) file consists of a series of surface attribute and rendering instructions formatted within curly braces ("{" and "}").

Below, you can see a simple example of (syntax/format) for a single process, including the Q3MAP keywords or "Surface Parameters", which follow the first bracket and a single bracketed "stage":

```
textures/liquids/lava
{
    deformVertexes wave sin 0 3 0 0.1
    tessSize 64
    {
        map textures/common/lava.tga
    }
}
```

Another way to look at a [shader], is to consider it a (virtualized texture), or a (*.psd) file.

When processing the (virtualized texture), the initial graphic is pulled into memory, and than additional (layers/calculations/functions) are applied to this virtual texture while in the (frame buffer/memory), which allows it to be [reproducible] and [scalable].

2.2 Shader Name & File Conventions

The first line is the [shader name], which can be up to (63) characters long.

The names are often a mirror of a pathname to a (*.tga) file without the extension or basedir

(/quake3/baseq3 in our case), but- they do not NEED to be.

```
However, whether using (*.png|jpg|tga) files in the global keywords like
  - qer_editorimage
  - q3map_lightimage

OR, a (map/clampmap) reference in an individual stage...

ALL extensions MUST be (*.tga), as the game engine converts all of those file types into (*.tga) in
memory while the game is running.

So if it's a (*.jpg), it's still gonna be (*.tga).
And if it's a (*.png), it's still gonna be a (*.tga).
```

Shaders that are only going to be referenced by the game code, not modeling tools, often are just a single world, like "projectionShadow" or "viewBlood".

Shaders that are used on characters or other polygon models need to mirror a (*.tga) file, which allows the modelers to build with normal textures, then have the special effects show up when the model is loaded into the game.

Shaders that are placed on surfaces in the map editor commonly mirror a (*.tga) file, but the "qer_editorimage" shader parameter can force the editor to use an arbitrary image for display.

```
Effectively, this means that the editor will show the [specified image] instead of the [base image], or
the [shader] after being rendered by the [game engine].
```

Shader pathnames have a case sensitivity issue - on Windows, they aren't case sensitive, but on (linux/unix), they are.

Try to always use lowercase for filenames, and always use forward slashes "/" for directory separators.

2.3 Shader Types

The keywords that affect shaders are divided into two classes.

The first class of keywords are [global parameters].

Some global parameters ("surfaceparms" and all "q3map_" keywords) are processed by Q3MAP, and change physical attributes of the surface that uses the shader, and these attributes can affect the player.

To see changes in these parameters, one must (re-bsp/recompile) the map.

The remaining [global keywords], and all [Stage Specific Keywords] are processed by the renderer.

They are only appearance changes, and have NO effect on game (play/mechanics).

Changes to any of these attributes will take effect as soon as the game goes to another level, or vid_restarts (type command vid_restart in the game console).

Shader keywords are NOT case sensitive.

IMPORTANT NOTE: some of the shader commands may be [order dependent], so it's good practice to place ALL global shader commands (keywords defined in this section) at the [very beginning of the shader], and to place shader stages at the end (see various examples).

```
I'll cover that later.
```

2.4 Key Concepts

Ideally, a (designer/artist) who is manipulating textures with (*.shader) files has a basic understanding of [wave forms] and knows about mixing [colored light] (high school physics sort of stuff).

If not, there are some [concepts] you need to have a grasp on, to make shaders work for you.

2.4.1 Surface Effects vs. Content Effects vs. Deformation Effects

[Shaders] not only modify the [visible aspect of textures] on a geometry (brush/curve/patch), or mesh model, but they can also have an effect on both the (content/shape/movement) of these objects.

A [surface effect] does NOTHING to modify the (shape/content) of the brush.

[Surface effects] include glows, transparencies and rgb (red, green, blue) value changes.

rgb = Red, Green, Blue, remember that.

[Content effects] affect the way the brush operates in the game world.
Examples include [water], [fog], [nonsolid], and [structural].

[Deformation effects] change the actual [shape] of the affected (brush/curve), and may make it appear to move.

2.4.2 Power Has a Price

The shader script gives the (designer/artist/programmer) a great deal of easily accessible power over the [appearance] of and potential [special effects] that may be applied to [surfaces in the game world].

But it is power that comes with a [price tag] attached, and the cost is measured in [performance speed].

Which means, [efficiency with shaders] is [key] to [high (performance/frame rate)].

Each [shader] phase that affects the [appearance] of a [texture] causes the engine to make another [processing pass] and [redraw the world].

Think of it as if you were adding all the shader-affected triangles to the total r_speed count for each stage in the shader script.

A shader-manipulated texture that is seen through another shader manipulated texture, for instance...
a light in fog, has the effect of adding the total number of passes together for the affected triangles.

A light that required (2) passes seen through a fog that requires (1) pass, will be treated as having to redraw that part of the world (3) times.

Think of it like this, you're just some guy, and you need to have a conversation with [Joe Pesci].
You don't know [Joe Pesci] yourself, but maybe your [mother] knows a guy who MIGHT know [Joe Pesci].
You ask your mother who that guy is, and she tells you who the guy is that she knows, that just MIGHT know [Joe Pesci]… so then you have to track that guy down.

You take your time trying to find that guy, because you can't rush this, because people are tempermental.
When you do, he may tell ya "I don't know him personally, but I know someone who might".

Alas, you're greeted with the [law of diminishing returns]…

You don't know [Joe Pesci], the guys you met along the way only [MIGHT] have known him…
…and you start to realize that you're putting a LOT of time into trying to track down [Joe Pesci],
in order to compliment him on his acting abilities in [My Cousin Vinny], or [Goodfellas].

2.4.3 RGB Color

RGB means "Red, Green, Blue." Mixing (red/green/blue) light in differing intensities creates the colors in computers and television monitors.

This is called [additive color] (as opposed to the mixing of pigments in paint or colored ink in the printing process, which is [subtractive color]).

In [Quake III Arena] and most higher-end computer art programs (and the color selector in Windows), the intensities of the individual (red/green/blue) components are expressed as [number values].

Like for instance, in HTML, you might see a code "#FFFFFF", which is hexadecimal for 255,255,255,
which will be [pure white]. However, in the editor and the game, these numbers are normalized to be
between 0 and 1 as a [floating point number].

When mixed together on a screen, number values of equal intensity in each component color create a completely neutral (gray) color.

The lower the number value (towards 0), the darker the shade.

The higher the value (towards 1), the lighter the shade or the more saturated the color until it reaches a maximum value of 255 (in the art programs).

All colors possible on the computer can be expressed as a formula of three numbers.

The value for complete black is 0 0 0.

The value for complete white is 255 255 255.

However, the [Quake III Arena] graphics engine requires that the color range be "normalized" into a range between 0.0 and 1.0 (<floating point numbers>).

2.4.4 Normalization: a Scale of 0 to 1

The mathematics in [Quake III Arena] use a scale of 0.0 to 1.0 instead of 0 to 255.

Most computer art programs that can express RGB values as numbers use the 0 to 255 scale.

To convert numbers, divide each of the art program's values for the component colors by 255.

The resulting (3) values are your [Quake III Arena] formula for that color component.

The same holds true for texture coordinates.

2.4.5 Texture Sizes

(*.tga) texture files are measured in pixels (picture elements).

Textures are measured in powers of (2), with (16x16) pixels being the smallest (typically) texture in use. Most will be larger.

Textures need not be [square], so long as [both dimensions] are powers of (2).
Examples include: (32x256), (16x32), (128x16).

2.4.6 Color Math

In [Quake III Arena], colors are changed by [mathematical equations] worked on the textures by way of the scripts or "programlets" in the shader file.

[Equations] that [add to] or [multiply] the values in a texture causes it to become [darker].

[Equations] that [subtract from] or [modulate/divide] values in a texture cause it to become [lighter].

Either [equation] can change the (hue/saturation) of a color.

2.4.7 Measurements

The measurements used in the [shaders] are in either (game/color/texture) units.

Game units	A game unit is used by deformations to specify sizes relative to the world. [Game units] are the same scale we have had since way back in the [Wolfenstein] days: (8) units equals (1) foot. The default texture scale used by the [Q3Radiant] map editor results in (2) texels for each game unit, but that can be freely changed.
Color units	Colors scale the values generated by the texture units to produce [lighting effects]. A value of 0.0 will be completely black A value of 1.0 will leave the texture unchanged. Colors are sometimes specified with a single value to be used across all red, green, and blue channels, or sometimes as separate values for each channel.
Texture units	These are the normalized dimensions of the original texture image, OR a previously modified texture at a given stage in the shader pipeline. A full texture, regardless of its original size in texels, has a normalized measurement of 1.0 x 1.0. For normal repeating textures, it is possible to have value greater than 1.0, or less than 0.0, resulting in repeating of the texture. The coordinates are usually assigned by the level editor or modeling tools, but you still need to be aware of this for scrolling or turbulent movement of the texture at runtime.

Sin	[Sin] stands for sine wave, a regular smoothly flowing wave ranging from -1 to 1.
Triangle	[Triangle] is a wave with a sharp ascent and a sharp decay, ranging from 0 to 1. It will make a choppy looking wave forms.
Square	A [square] wave simply switches from -1 to 1 with no in-between.

Sawtooth	In the [sawtooth] wave, the ascent is like a triangle wave from 0 to 1, but the decay cuts off sharply back to 0.
InverseSawtooth	This is the reverse of the [sawtooth] ... instant ascent to the peak value (1), then a triangle wave descent to the valley value (0). The phase on this goes from 1.0 to 0.0 instead of 0.0 to 1.0. This wave is particularly useful for additive cross-fades.

[Waveforms] all have the following (properties/parameters):

base	Where the [wave form] begins. [Amplitude] is measured from this [base value].
amplitude	This is the [height] of the wave created, measured from the [base]. You will probably need to (test/tweak) this value to get it correct for [each new shader stage]. The greater the [amplitude], the higher the wave peaks and the deeper the valleys.
phase	This is a normalized value between (0.0) and (1.0). Changing [phase] to a [non-zero value] affects the [point] on the wave at which the wave form initially begins to be plotted. Example: In (sin/triangle) wave, a phase of "0.25" means it begins one fourth (25%) of the way along the curve, or more simply put, it begins at the peak of the wave. A phase of (0.5) would begin at the point the wave re-crosses the base line. A phase of (0.75) would be at the lowest point of the valley. If only (1) wave form is being used in a shader, a phase shift will probably not be noticed, and phase should have a value of zero (0). However, including (2+) stages of the same process in a single shader, but with the phases shifted can be used to create interesting visual effects. Example: using [rgbGen] in (2) stages with different colors and a (0.5) difference in [phase] would cause the manipulated texture to modulate between (2) distinct colors. [Phase] changes can also be used when you have (2) uses of the same effect near each other, and you don't want them to be [synchronized]. You would write a separate shader for each, changing only the [phase] value.
frequency	[Frequency], this value is expressed as [repetitions] or [cycles] of the wave [per second]. A value of (1) would cycle (1) time per second. A value of (10) would cycle (10) times per second. A value of (0.1) would cycle once every (10) seconds.

3. General Shader Keywords

IMPORTANT NOTE: Once again, be aware that some of the [shader commands] may be [order dependent], so it's [good practice] to place ALL [global shader commands] (keywords defined in this section) at the very [beginning]
of the [shader], and to place [shader stages] at the end (see various examples).

These [Keywords] are [global] to a [shader] and affect ALL stages. They are also ignored by Q3MAP.

3.1 skyParms <farbox> <cloudheight> <nearbox>

Specifies how to use the [surface] as a [sky], including an optional [far box] (stars/moon/etc/), optional [cloud layers] with any [shader attributes], and an optional [near box] (mountains in front of the clouds, etc).

farbox	Specifies a set of files to use as an [environment box] behind all [cloud layers]. Specify "-" for [no farbox], or a [file base name]. A base name of "env/test" would look for files: "env/test_rt.tga" | [Right] "env/test_lf.tga" | [Left] "env/test_ft.tga" | [Front] "env/test_bk.tga" | [Back] "env/test_up.tga" | [Up]

	"env/test_dn.tga" | [Down]
cloudheight	Controls apparent [curvature] of the [cloud layers]. [Lower height values] mean [more curvature], and thus more horizon distortion. [Higher height values] mean [less curvature], and thus less horizon distortion. Think of [height] as the [radius] of a [sphere] on which the [clouds] are [mapped]. Good ranges are (64) to (256), and the default value is (128).
nearbox	Specified as [farbox], to be [alpha blended] on [top] of the [clouds]. This has not been tested in a long time, so it probably doesn't actually work. Set to "-" to ignore.

[Design Notes]:

- If you are making a map where the [sky] is seen by looking [up] most of the time,
  [use a lower cloudheight value].

  Under those circumstances the [tighter curve] looks [more dynamic].

  If you are making a map where the [sky] is seen by looking [out windows] most of the time,
  or has a map area that is [open to the sky] on (1+) sides, use a [higher height] to make the
  [clouds] seem [more natural].

- It is possible to create a [sky] with up to (8) cloud layers, but that also means (8)
  processing passes, and a potentially [large processing hit].

- Be aware that the [skybox] does not wrap around the [entire world].
  The "floor" or bottom face of the skybox is not drawn by the game.

  If a player in the game can see that face, they will see the "hall of mirrors" effect.

[Example]: Sky script

```
textures/skies/xtoxicsky_dm9
{
    qer_editorimage textures/skies/toxicsky.tga
    surfaceparm noimpact
    surfaceparm nolightmap
    q3map_globaltexture
    q3map_lightsubdivide 256
    q3map_surfacelight 400
    surfaceparm sky
    q3map_sun 1 1 0.5 150 30 60
    skyparms full 512 -
    {
        map textures/skies/inteldimclouds.tga
        tcMod scroll 0.1 0.1
        tcMod scale 3 2
    }
}
```

3.2 cull <side>

Every surface of a [polygon] has (2) sides, (front/back).

Typically, we only see the front or "out" side.

For example, a [solid block] you only show the [front side].

In many applications we see [both].

For example, in [water], you can see both [front] and a [back].

The same is true for things like [grates] and [screens].

To "cull" means to remove.
The [value] parameter determines the type of face culling to apply.
The default value is cull [front] if this keyword is not specified.

However, for items that should be [inverted] then the value [back] should be used.

To disable culling, the value [disable] or [none] should be used.

Only (1) cull instruction can be set for the shader.

3.2.1 cull front
The front or "outside" of the polygon is not drawn in the world.

This is the default value.

It is used if the keyword "cull" appears in the content instructions without a <side> value or if the keyword cull does not appear at all in the shader.

3.2.2 cull back
Cull back removes the back or "inside" of a polygon from being drawn in the world.

3.2.3 cull disable, cull none
Neither side of the polygon is removed. Both sides are drawn in the game.

Very useful for making [panels] or [barriers] that have [no depth], such as [grates], [screens], [metal wire fences] and so on, and for [liquid volumes] that the player can see from within.

Also used for [energy fields], [sprites], and [weapon effects] (e.g.; plasma).

Design Notes: For things like [grates] and [screens], put the [texture] with the cull none property on (1) face only. On the other faces, use a non-drawing texture.

3.3 deformVertexes
This function performs a [general deformation] on the surface's [vertexes], changing the actual [shape] of the [surface] before drawing the [shader passes].

You can stack [multiple deformVertexes] commands to modify positions in more complex ways, making an object move in two dimensions, for instance:

3.3.1 deformVertexes wave <func> <base> <amplitude> <phase> <freq>
Designed for [water surfaces], modifying the values differently at each point.

It accepts the standard [wave functions] of the type (sin/triangle/square/sawtooth/inversesawtooth).

The "div" parameter is used to control the wave "spread" - a value equal to the [tessSize] (tesselation size) of the surface is a good default value ([tessSize] is subdivision size, in game units, used for the shader when seen in the game world).

3.3.2 deformVertexes normal <func> <base> <amplitude (0.1-0.5)> <frequency (1.0-4.0)>

This [deformation] affects the normals of a vertex without actually moving it, which will effect later shader options like [lighting] and especially [environment mapping]. If the shader stages don't use normals in any of their calculations, there will be [no visible effect].

Specific parameter definitions for deform keywords:

div	This is roughly defined as the [size of the waves that occur]. It is measured in [game units]. [Smaller values] create a [greater density] of [smaller wave forms] occurring in a given area. [Larger values] create a [lesser density] of waves, or otherwise put, the appearance of [larger waves]. To look [correct] this value should closely correspond to the value (in pixels) set for [tessSize] (tessellation size) of the texture. A value of (100.0) is a good default value (which means your [tessSize] should be close to that for things to look "wavelike").
func	This is the [type] of [wave] form being created. [Sin] stands for [sine wave], a regular smoothly flowing wave.

	[Triangle] is a wave with a [sharp ascent] and a [sharp decay]. It will make a [choppy looking wave forms]. A [square wave] is simply (on/off) for the period of the [frequency] with [no in between]. The [sawtooth wave] has the [ascent] of a [triangle wave], but has the [decay] cut off [sharply] like a [square wave]. An [inversesawtooth wave] reverses this.
base	This is the [distance], in [game units] that the apparent [surface] of the [texture] is [displaced] from the [actual surface] of the [brush] as placed in the [editor]. A positive value appears [above] the [brush surface]. A negative value appears [below] the [brush surface]. An example of this is the [Quad effect], which essentially is a shell with a [positive base value] to stand it away from the model surface, and a (0) value for [amplitude].
amplitude	The [distance] that the [deformation] moves [away] from the [base value]. See [Wave Forms] in the [introduction] for a [description] of [amplitude].
phase	See [Wave Forms] in the [introduction] for a [description] of [phase].
frequency	See [Wave Forms] in the [introduction] for a [description] of [frequency].

Design Note: The [div] and [amplitude] parameters, when used in [conjunction] with [liquid volumes] like [water], should take into consideration [how much the water will be moving]. A [large ocean area] would have have [massive swells] (big div values) that rose and fell dramatically (big amplitude values), while a [small], [quiet pool] may move [very little].

Putting values of (0.1) to (0.5) in [Amplitude] and (1.0) to (4.0) in the [Frequency] can produce some satisfying results.

Some things that have been done with it: A small fluttering bat, falling leaves, rain, flags.

3.3.3 deformVertexes bulge <bulgeWidth> <bulgeHeight> <bulgeSpeed>

This forces a [bulge] to move along the given <s> and <t> directions. Designed for use on [curved pipes].

3.3.4 deformVertexes move <x> <y> <z> <func> <base> <amplitude> <phase> <freq>

This [keyword] is used to make a (brush/curve patch/model) appear to [move] together as a [unit].

The <x> <y> and <z> values are the distance and direction in game units the object appears to move relative to its' point of origin in the map.

The <func> <base> <amplitude> <phase> and <freq> values are the same as found in other [wave form manipulations].

The [product] of the [function] modifies the values (x/y/z).

Therefore, if you have an [amplitude] of (5) and an [x] value of (2), the object will travel (10) units from its' [point of origin] along the [x-axis].

This results in a total of (20) units of motion along the [x-axis], since the [amplitude] is the [variation] both (above/below) the [base].

It MUST be noted, that an [object] made with this [shader] does not actually [change position], it only [appears] to.

Design Note: If an [object] is made up of [surfaces] with [different shaders], ALL MUST have [matching deformVertexes move values], or the [object] will appear to [tear itself apart].

3.3.5 deformVertexes autosprite

This [function] can be used to make any given triangle quad (pair of triangles that form a square rectangle) [automatically] behave like a [sprite] without having to make it a [separate entity].

This means that the "sprite" on which the [texture] is placed, will [rotate] to always appear at [right angles] to the [player's view] as a [sprite] would.

Any (4) sided (brush side/flat patch/pair of triangles in a model) can have the [autosprite] effect on it.

The [brush face] containing a [texture] with this [shader keyword] must be [square].

Design Note: This is best used on [objects] that would [appear the same], regardless of [viewing angle]. An example might be a [glowing light flare].

3.3.6 deformVertexes autosprite2

Is a slightly modified "sprite" that only rotates around the [middle] of its [longest axis].

This allows you to make a [pillar of fire] that you can [walk around], or an [energy beam] stretched across the room.

3.4 fogparms <red> <green> <blue> <distance to Opaque>

Note: you must also specify "surfaceparm fog" to get [q3map] to [identify the surfaces inside the volume].

[Fogparms] only describes how to render the fog on the [surfaces].

<red> <green> <blue> are [normalized values].

A good computer art program should give you the RGB values for a color.

To obtain the values that define fog color for [Quake III Arena], divide the desired color's <red>, <green> and <blue> values by (255) to obtain (3) normalized numbers within the (0.0) to (1.0) range.

<distance to opaque> This is the [distance], in [game units], until the [fog] becomes [totally opaque], as measured from the point of view of the observer.

By making the [height] of the [fog brush] shorter than the [distance to opaque], the apparent [density] of the [fog] can be [reduced] because it [never reaches the depth] at which [full opacity] occurs.

- The [fog volume] can only have (1) surface visible, from [outside the fog]
- [Fog] must be made of [one brush], it cannot be made of adjacent brushes
- [Fog brushes] must be [axial], meaning that only (square/rectangular) brushes may contain fog, and those must have their edges drawn along the axes of the map grid (all (90) degree angles)

Design Notes:
- If a [water texture] contains a [fog parameter], it must be treated as if it were a [fog texture] when in use
- If a room is to be [completely filled] with a [fog volume], it can ONLY be [entered] through (1) surface and still have the fog function correctly
  - [Additional shader passes] may be placed on a [fog brush], as with other brushes.

3.5 nopicmip

This causes the [texture] to [ignore user-set values] for the [r_picmip cvar command].

The image will ALWAYS be [high resolution].

Example: Used to keep (images/text) in the (HUD/heads up display) from [blurring] when user optimizes the game graphics.

3.6 nomipmap

This implies [nopicmip], but also prevents the generation of any[lower resolution mipmaps] for use by the (GPU/graphics processing unit). This will cause the [texture] to [alias] when it gets [smaller], but there are some cases where you would [rather] have this than a [blurry image].

Sometimes [thin slivers of triangles] force things to [very low mipmap levels], which leave a few [constant pixels] on otherwise [scrolling special effects].

3.7 polygonOffset

Surfaces rendered with the [polygonOffset] keyword are rendered [slightly off] the polygon's [surface]. This is typically used for (wall markings/decals), the [distance] between the [offset] and the [polygon] is [fixed].

It is not a [variable] in [Quake III Arena].

3.8 portal

Specifies that this [texture] is the [surface] for a (portal/mirror).

In the game map, a [portal entity] must be placed [directly in front of the texture], within (64) [game units].

All this does is set "sort portal", so it isn't [needed] if you specify that [explicitly].

3.9 sort <value>

Use this [keyword] to fine-tune the [depth sorting] of [shaders] as they are compared against [other shaders] in the [game world].

The basic concept, is that if there is a (question/problem) with [shaders] drawing in the [wrong order] against each other, this allows the [designer] to create a [hierarchy] of which [shader] draws in [what order].

The [default] behavior is to put ALL blended shaders in sort "additive", and all [other shaders] in sort "opaque", so you only need to specify this when you are trying to work around a sorting problem with [multiple transparent surfaces] in a scene.

The value here can be either a [numerical value] or one of the [keywords] in the following list (listed in order of ascending priority):

portal	(1)	This surface is a [portal], it draws over [every other shader] seen inside the [portal], but before anything in the [main view].
sky	(2)	Typically, the [sky] is the [farthest surface] in the [game world]. Drawing this after other opaque surfaces can be an optimization on some cards. This currently has the [wrong value] for this purpose, so it doesn't do much.
opaque	(3)	This surface is [opaque], rarely needed since this is the default with no [blendfunc].
banner	(6)	[Transparent], but very close to walls.
underwater	(8)	Draw [behind] normal transparent surfaces.
additive	(9)	normal transparent surface, default for shaders with [blendfuncs].
nearest	(16)	this shader should always sort [closest] to the [viewer], (muzzle flashes/blend blobs)

4. Q3MAP Specific Shader Keywords

These [keywords] change the [physical nature] of the [textures] and the [brushes] that are marked with them.

Changing any of these values will require the [map] to be [recompiled].

These are [global] and affect the [entire shader].

4.1 tessSize <amount>

For consistency's sake, this really should have been called q3map_tessSize ... but- it wasn't.

The [tessSize] shader controls the [tessellation size] (how finely a surface is chopped up in to triangles), in game units,
of the surface.

This is only applicable to s[olid brushes], not curves, and is generally only used on surfaces that are flagged with the [deformVertexes] keyword.

[Abuse] of this can create a [huge number of triangles].

This happens during [q3map] processing, so maps must be [reprocessed] for changes to take effect.

Design Note: It can also be used on [tesselating surfaces] to make sure that [tesselations] are [large], and thus,
[less costly in terms of triangles created].

4.2 q3map_backshader <shadername>

This allows a [brush] to use a [different shader] when you are [inside it → looking out].

By way of example, this would allow a [water brush] (or other) surfaces to have a different sort order (see sort above) or appearance when seen from the inside.

4.3 q3map_globaltexture

Use this [shader] in the [global keyword commands] whenever the [tcMod] scale function is used in one of the later render stages.

Many problems with getting [shader effects] to work across [multiple adjacent brushes] are a result of the way [q3map optimizes texture precision].

This option resolves that, but at the [expense] of some [precision] of the [textures] when they are [far away from the origin of the map].

4.4 q3map_sun <red> <green> <blue> <intensity> <degrees> <elevation>

This keyword in a [sky shader] will create the [illusion] of [light] cast into a map by a single, infinitely distance light source (sun/moon/hell/fire/etc).

This is only processed during the [lighting phase] of [q3map].

<red> <green> <blue> Color is described by three normalized rgb values.
Color will be normalized to a (0.0) to (1.0) range, so it doesn't matter what range you use.

<intensity> is the [brightness] of the [generated light].

A value of (100) is a [fairly bright sun].

The [intensity] of the [light] falls off with [angle] but not [distance].

<degrees> is the [angle] relative to the [directions on the map file].

A setting of (0) degrees equals east.
(90) is north, (180) is west and (270) is south.

<elevation> is the [distance], measured in [degrees] from the [horizon] ([z-value] of (0) in the map file).
An elevation of (0) is (sunrise/sunset).
An elevation of (90) is noon.

DESIGN NOTE: [Sky shaders] should probably still have a [q3map_surfacelight] value.

The "sun" gives a strong directional light, but doesn't necessarily give the [fill light] needed to (soften/illuminate) shadows.

Skies with [clouds] should probably have a weaker [q3map_sun] value and a higher [q3map_surfacelight] value.

Heavy clouds [diffuse light] and [weaken shadows], while the opposite is true of a (nearly*) cloudless sky.

In such cases, the "sun" or "moon" will cast stronger, shadows that have a greater degree of contrast.

Design Trick: Not certain what color formula you want to use for the sun's light? Try this ...
- Create a light entity
- Use the [Q3Radiant] editor's color selection tools to pick a color
- The light's _color key's value will be the [normalized RGB formula]
- Copy it from the [value line] in the [editor] (CTRL+C) and paste it into your shader
- Boom, now you're an expert

4.5 q3map_surfaceLight <light value>

The texture gives off light equal to the <light value> set for it.
The relative [surface area] of the [texture] in the [world] affects the actual [amount of light] that appears to be [radiated].

To give off what appears to be the same amount of light, a [smaller texture] must be [significantly brighter] than a [larger texture].

Unless the qer_lightimage keyword is used to select a different source for the texture's light color information, the [color] of the
[light] will be the [averaged color] of the [texture].

4.6 q3map_lightimage <texturepath/texturename>

The keyword [q3map_lightimage] generates [lighting] from the [average color] of the (*.tga) image specified by the [q3map_lightimage].

The [keyword sequence] for generating light on a [q3map_surfacelight] should be ordered as follows:
1) [q3map_lightimage], the texture providing the light and the color of the light

2) [qer_editorimage], the editor-only image used to select the source map for the texture
3) the [average color] of the [light] emitted from the [shader] is calculated from the [lightimage]

The reason [q3map_lightimage] is specified for the [light] in the example below, is because the [blend map] is predominantly [yellow],
and the designer wanted more yellow light to be emitted from the light.

[Example]: Taking light from another source texture

```
textures/eerie/ironcrosslt2_10000
{
    q3map_lightimage textures/gothic_light/ironcrosslt2.blend.tga // source for color of blended light
    qer_editorimage textures/gothic_light/ironcrosslt2.tga        // base TGA, uses multiple light vals
    q3map_surfacelight 10000                                      // emitted light value of 10,000
    {
        map $lightmap                                             // source affected by lightmap
        rgbGen identity                                           // handles "sunlight" overbright bits
    }
    {
        map textures/gothic_light/ironcrosslt2.tga
        blendFunc filter
        rgbGen identity
    }
    {
        map textures/gothic_light/ironcrosslt2.blend.tga
        blendFunc add
    }
}
```

4.7 q3map_lightsubdivide <value>
This allows the user to define how large, or small to make the subdivisions (triangles) in a textured surface, particularly aimed at light-emitting textures like skies.It defaults to (120) game units, but can be made larger (256-512) for [sky boxes] or smaller for light surfaces at the bottoms of cracks.
This can be a dominant factor in processing time for [q3map lighting].

4.8 surfaceparm <parm>
All [surfaceparm keywords] are preceded by the word [surfaceparm] as follows: [surfaceparm fog] or [surfaceparm noimpact].

4.8.1 alphashadow
This keyword applied to a [texture] on a (brush/patch/model) will cause the [lighting phase] of the [q3map process] to use the texture's [alpha channel] as a [mask] for casting [static shadows] in the [game world].

Design Note: [Alphashadow] does not work well with [fine line detail on a texture].

Fine lines may not cast acceptable shadows.

> ...at least in [Quake III Arena], whereas [Doom 3] is a totally different story.

It appears to work best with [well-defined silhouettes] and [wider lines] within the [texture].

Most of our [tattered banners] use this, to cast [tattered shadows].

4.8.2 areaportal
A [brush] marked with this [keyword] functions as an [area portal], a break in the Q3MAP tree.

It is typically placed on a [very thin brush] placed inside a [door entity],
but is not a part of that entity.

The intent is to [block the game from processing surface triangles located behind it when the door is closed].

It is also used by the BSPC (bot area file creation compiler) in the same manner as a [cluster portal].

The [brush] MUST touch ALL the [structural brushes] surrounding the [areaportal].

4.8.3 clusterportal
A [brush] marked with this [keyword function] creates a [subdivision] of the (area file/*.aas) used by [bots] for [navigation].

It is typically placed in locations that are [natural breaks in a map], such as entrances to (halls/doors/tunnels/etc.)

The intent is keep the bot from having to process the entire map at once.

As with the the [areaportal parameter], the affected brush must touch ALL of the [structural brushes] surrounding the [areaportal].

4.8.4 donotenter
Read as "do not enter." Like clusterportal, this is a [bot-only property].

A [brush] marked with [donotenter] will not affect non-bot players, but [bots will not enter it].

It should be used only when bots appear to have difficulty navigating around some map features.

4.8.5 flesh
This will cue different sounds (in a similar manner to [metalsteps]) and cause [blood] to appear, instead of [bullet impact flashes].

4.8.6 fog
[Fog] defines the [brush] as being a "fog" [brush].

This is a [Q3MAP function] that (chops/identifies) ALL geometry inside the brush.

The [general shader keyword] "fogparms" must ALSO be specified, to tell how to draw the fog.

4.8.7 lava
Assigns to the [texture] the game properties set for [lava].

This affects both the [surface] and the [content] of a [brush].

4.8.8 metalsteps
The player sounds as if he is walking on clanging metal (steps/gratings).

Other than specifiying (flesh/metalsteps/nosteps/default), it is currently not possible for a [designer] to (create/assign) a specific sound routine to a [texture].

Note: If NO sound is set for a texture, then the [default] footsteps sound routines are heard.

4.8.9 nodamage
The player takes [no damage] if they fall onto a [texture] with this [surfaceparm].

4.8.10 nodlight
Read as "No Dee Light", a [texture] containing this parameter will not be (affected/lit) by [dynamic lights], such as [weapon effects].

An example in [Quake III Arena] would be [solid lava].

4.8.11 nodraw
A [texture] marked with [nodraw] will not [visually appear] in the game world.

Most often used for (triggers/clip brushes/origin brushes/etc.)

4.8.12 nodrop
When a [player] dies inside a (volume/brush) marked [nodrop], [no weapon is dropped].

The intended use is for "Pits of Death."

Have a [kill trigger] inside a [nodrop volume], and when players die there ... they won't [drop their weapons].

The intent is to prevent unnecessary polygon pileups on the floors of pits.

4.8.13 noimpact
[World entities] will NOT impact on this [texture].

No [explosions] occur when [projectiles] strike this surface, and [no marks] will be left on it.

[Sky textures] are usually marked with this texture, so those [projectiles] will NOT (hit the sky/leave marks).

4.8.14 nomarks
[Projectiles] will [explode] upon [contact] with this [surface], but [will not leave marks].

[Blood] will ALSO not mark this surface.

This is useful to keep [lights] from being [temporarily obscured] by [battle damage].

Design Note: Use this on ANY surface with a [deformVertexes keyword].

Otherwise, the marks [will appear] on the unmodified surface location of the texture
with the surface (wriggles/squirms) through the marks.

4.8.15 nolightmap
This texture does not have a lightmap phase.

It is NOT affected by the [ambient lighting] of the [world] around it.

It does not require the addition of an [rgbGen] identity keyword in that stage.

4.8.16 nosteps
The player makes [no sound] when walking on this [texture].

4.8.17 nonsolid
This attribute indicates a [brush], which does not block the movement of [entities] in the [game world].

It applies to (triggers/hint brushes/similar brushes).

This affects the [content] of a [brush].

4.8.18 origin
Used on the "origin" texture.

[Rotating entities] need to contain an [origin brush] in their construction.

The brush must be (rectangular/square).

The [origin point] is the [exact center] of the [origin brush].

4.8.19 playerclip
[Blocks player movement] through a [nonsolid texture].

Other [game world entities] can pass through a brush marked playerclip.

The intended use for this, is to [block the player] but NOT block [projectiles] like [rockets].

4.8.20 slick
This [surfaceparm] included in a [texture] should give it [significantly reduced friction], like [ice].

4.8.21 slime
Assigns to the [texture] the [game properties] for [slime].

This affects both the [surface] and the [content] of a [brush].

4.8.22 structural
This [surface attribute] causes a [brush] to be seen by the [Q3MAP process] as a possible
break-point in a BSP tree.

It is used as a part of the shader for the "hint" texture.

Generally speaking, [any opaque texture] NOT marked as "detail" is structural by default,
so you shouldn't need to specify this.

4.8.23 trans
Tells [q3map] that [pre-computed visibility] should NOT be [blocked] by this [surface].

Generally, any shaders that have [blendfuncs] should be marked as [surfaceparm trans].

4.8.24 water
Assigns to the [texture] the [game properties] for [water].

5. Editor-specific shader instructions

These instructions only affect the [texture] when it is seen in [Q3Radiant].

They [should be grouped] with the [surface parameters], but [ahead of them] in sequence.

5.1 qer_editorimage <texture path/texturename>

This [keyword] creates a [shader name] in memory, but in the [editor], it displays the (*.tga) art image specified in [qer_editorimage]
(in the example below this, is "textures/eerie/lavahell.tga").

The [editor] maps a [texture] using the [size attributes] of the [(*.tga) file] used for the [editor image].

When that [editor image] represents a [shader], any [texture] used in any of the [shader stages] will be scaled (up/down) to the dimensions of the [editor image].

If a (128x128) pixel image is used to represent the [shader] in the [editor], then a (256x256) image used in a later stage will be shrunk to fit.

A (64x64) image would be stretched to fit.

Be sure to check this on (bounce/acceleration/power-up) pads placed on surfaces other than (256x256).

Use [tcMod scale] to [change the size of the stretched texture].

Remember that [tcMod scale 0.5 0.5] will (2x) your image, while [tcMod scale 2 2] will (1/2) it.

Design Notes: The [base_light] and [gothic_light] shaders contain numerous uses of this.

It can be [very useful] for making [different light styles], mostly to change the light brightness without having to create a new piece of
(*.tga) art for each new shader.

```
textures/liquids/lavahell2                      // path and name of new texture
{
    qer_editorimage textures/eerie/lavahell.tga // based on this
    qer_nocarve                                 // cannot be cut by CSG subtract
    surfaceparm noimpact                        // projectiles do not hit it
    surfaceparm lava                            // has the game properties of lava
    surfaceparm nolightmap                      // environment lighting does not affect
    q3map_surfacelight 3000                     // light is emitted
    tessSize 256                                // relatively large triangles
    cull disable                                // no sides are removed
    deformVertexes wave 100 sin 5 5 .5 0.02
    fogparms 0.8519142 0.309723 0.0 128 128
    {
        map textures/eerie/lavahell.tga         // base texture artwork
        tcMod turb .25 0.2 1 0.02               // texture is subjected to turbulence
        tcMod scroll 0.1 0.1                    // the turbulence is scrolled
    }
}
```

5.2 qer_nocarve

A [brush] marked with this [instruction] will NOT be affected by [CSG subtract functions].

It is especially useful for (water/fog/lava) textures.

5.3 qer_trans <value>

This parameter defines the [percentage of transparency] that a [brush] will have when seen in the [editor], but no effect on rendering in-game.

It can have a positive value between (0-1).

The HIGHER the value, the [less transparent] the texture.

Example: [qer_trans 0.2] means the brush is (20%) opaque, and [nearly invisible].

6. Stage Specific Keywords

[Stage specifications] only affect [rendering].

Changing ANY (keywords/values) within a [stage] will usually take effect as soon as a [vid_restart] is executed.

[Q3MAP] ignores [stage-specific keywords] entirely.

A [stage] can specify a (texture map/color function/alpha function/texture coordinate function/blend function), and a few other rasterization options.

6.1 Texture map specification

6.1.1 map <texturepath/texturename>

Specifies the source texture map, a (24/32)-bit [(*.tga) file] used for this stage.

The texture may or may not contain [alpha channel] information.

The special keywords $lightmap and $whiteimage may be substituted in lieu of an [actual texture map name].

In those cases, the [texture] named in the [first line] of the [shader] becomes the [texture] that [supplies the light mapping data] for the process.

$lightmap
This is the [overall lightmap] for the [game world].

It is [calculated] during the [Q3MAP process].

It is the [initial color data] found in the [framebuffer].

Critical note: Due to the use of [overbright bits] in [light calculation], the keyword [rgbGen identity] must accompany ALL $lightmap instructions.

$whiteimage
This is used for [specular lighting] on (*.md3/models).

This is is a [white image] generated internally by the [game].

This image can be used in lieu of $lightmap, or an [actual texture map] if, for example, you wish for the [vertex colors] to come through [unaltered].

6.1.2 clampmap <texturepath>

Dictates that [this stage] should [clamp texture coordinates] instead of [wrapping] them.

During a [stretch] function, the area, which the texture must cover during a wave cycle, (enlarges/decreases).

Instead of [repeating] a [texture] multiple times during [enlargement], or seeing only a [portion] of the [texture] during shrinking, the [texture dimensions] (increase/contract) accordingly.

This is only relevant when using something like [deformTexCoordParms] to (stretch/compress) texture coordinates for a specific special effect.

Remember that the [Quake III Arena] engine [normalizes] ALL texture coordinates, regardless of actual texture size, into a scale of (0.0-1.0).

Proper Alignment: When using [clampTexCoords], make sure the [texture] is [properly aligned] on the [brush].

The [clampTexCoords] function keeps the image from [tiling].

However, the [editor] doesn't represent this properly, and shows a [tiled image].

Therefore, what appears to be the [correct position] may be [offset].

This is [very apparent] on anything with a [tcMod rotate] and [clampTexCoords] function.

Avoiding Distortion: When seen at a given distance, which can vary depending on hardware and the size of the texture ... the [compression phase] of a [stretch function] will cause a "cross-like" [visual artifact] to form on the [modified texture] due to the [way] that [textures] are [reduced].

This occurs because the [texture] undergoing [modification] lacks sufficient "empty space" around the displayed (non-black) part of the texture (see figure 2a).

To [compensate] for this, make the [non-zero portion] of the [texture] substantially smaller
(50% of maximum stretched size -- see figure 2b) than the [dimensions] of the [texture].

Then, write a [scaling function/tcScale] into the appropriate [shader phase],
to [enlarge] the [image] to the [desired proportion].

The [shaders] for the [bouncy pads] in the [sfx.shader] file show the [stretch function] in use, including
the [scaling] of the [stretched texture]:

Example: Using [clampTexCoords] to control a [stretching texture]

```
textures/liquids/lavahell2 // path and name of new texture
{
    // q3map_surfacelight 2000
    surfaceparm nodamage
    q3map_lightimage textures/sfx/jumppadsmall.tga
    q3map_surfacelight 400
    {
        map textures/sfx/metalbridge06_bounce.tga
        rgbGen identity
    }
    {
        map $lightmap
        rgbGen identity
        blendfunc gl_dst_color gl_zero
    }
    {
        map textures/sfx/bouncepad01b_layer1.tga
        blendfunc gl_one gl_one
        rgbGen wave sin .5 .5 0 1.5
    }
    {
        clampmap textures/sfx/jumppadsmall.tga
        blendfunc gl_one gl_one
        tcMod stretch sin 1.2 .8 0 1.5
        rgbGen wave square .5 .5 .25 1.5
    }
}
```

6.1.3 AnimMap <frequency> <texture1> ... <texture8>

The [surfaces] in the game can be [animated] by displaying a sequence of (1-8) frames, via separate
[texture maps].

These [animations] are [affected by other keyword effects] in the (same/later) [shader stages].

<Frequency>: the `# of times that the [animation cycle] will [repeat] within a (1) second time period.

The [larger] the value, the [more repetitions per second].
[Animations] that should last for MORE than a second need to be expressed as [decimal values].

<texture1> ... <texture8>: the (texturepath/texture name) for [each animation frame] must be [explicitly
listed].

Up to (8) (frames/separate (*.tga) files) can be used to make an [animated sequence].

Each [frame] is displayed for an [equal subdivision] of the [frequency value].

Example: AnimMap 0.25
         "textures/sfx/b_flame1.tga"
         "textures/sfx/b_flame2.tga"
         "textures/sfx/b_flame3.tga"
         "textures/sfx/b_flame4.tga"

         ...would be a (4) frame animated sequence, calling each frame in sequence over a cycle
          length of (4) seconds.

         Each frame would be displayed for (1) seconds before the next one is displayed.

         The cycle [repeats] after the [last frame] in sequence is shown.

Design Notes: To make a [texture] image appear for an unequal (longer) amount of time
              (compared to other [frames]), repeat that [frame] multiple times in the sequence.

```
textures/sfx/flameanim_blue
{
    // ************************************************
    // * Blue Flame *
    // * July 20, 1999 Surface Light 1800 *
    // *Please Comment Changes *
    // ************************************************
    qer_editorimage textures/sfx/b_flame7.tga
    q3map_lightimage textures/sfx/b_flame7.tga
    surfaceparm trans
    surfaceparm nomarks
    surfaceparm nolightmap
    cull none
    q3map_surfacelight 1800
    // texture changed to blue flame.... PAJ
    {
        animMap 10 textures/sfx/b_flame1.tga
        textures/sfx/b_flame2.tga
        textures/sfx/b_flame3.tga
        textures/sfx/b_flame4.tga
        textures/sfx/b_flame5.tga
        textures/sfx/b_flame6.tga
        textures/sfx/b_flame7.tga
        textures/sfx/b_flame8.tga
        blendFunc GL_ONE GL_ONE
        rgbGen wave inverseSawtooth 0 1 0 10
    }
    {
        animMap 10 textures/sfx/b_flame2.tga
        textures/sfx/b_flame3.tga
        textures/sfx/b_flame4.tga
        textures/sfx/b_flame5.tga
        textures/sfx/b_flame6.tga
        textures/sfx/b_flame7.tga
        textures/sfx/b_flame8.tga
        textures/sfx/b_flame1.tga
        blendFunc GL_ONE GL_ONE
        rgbGen wave sawtooth 0 1 0 10
    }
    {
        map textures/sfx/b_flameball.tga
        blendFunc GL_ONE GL_ONE
        rgbGen wave sin .6 .2 0 .6
    }
}
```

6.2 Blend Functions

[Blend functions] are the [keyword commands] that tell the [Quake III Arena] graphic engine's [renderer] how [graphic layers] are to be [mixed together].

6.2.1 Simplified blend functions

The most common [blend functions] are set up here, as simple commands, and should be used unless you really know what you are doing.

6.2.1.1 blendfunc add

This is a shorthand command for [blendfunc gl_one gl_one].

Effects like (fire/energy) are [additive].

6.2.1.2 blendfunc filter

This is a [shorthand command] that can be substituted for either [blendfunc gl_dst_color gl_zero] or [blendfunc gl_zero gl_src_color].

A [filter] will ALWAYS result in [darker pixels] than what is behind it, but it can also [remove color] selectively.

[Lightmaps] are [filters].

6.2.1.3 blendfunc blend

Shorthand for [blendfunc gl_src_alpha gl_one_minus_src_alpha].

This is [conventional transparency], where part of the [background] is [mixed] with part of the [texture].

6.2.2 Explicit blend functions

Getting a [handle] on [this concept] is [absolutely key] to understanding ALL [shader manipulation] of [graphics].

[BlendFunc] or "Blend Function" is the [equation] at the core of [processing shader graphics].

The formula reads as follows:
[Source * <srcBlend>] + [Destination * <dstBlend>]

[Source] is usually the [RGB color data] in a (texture/(*.tga) file) modified by any [rgbgen] and [alphagen].

In the [shader], the [source] is generally identified by command [map], followed by the [name of the image].

[Destination] is the [color data] currently existing in the [frame buffer].

Rather than think of the [entire texture] as a [whole], it may be easier to think of the [number values] that correspond
to a [single pixel], because that is what the computer is processing, (1)pixel of the [bit map] at a time.

The [process] for calculating the [final look of a texture] in place in the [game world] begins with the [precalculated lightmap]
for the area where the [texture] will be located.

This [data] is in the [frame buffer], that is to say, it is the initial data in the [Destination].

In an [unmanipulated texture] (i.e.; one without a special shader script), [color information] from the [texture] is combined
with the [lightmap]. In a [shader-modified texture], the [$lightmap] stage MUST be present for the [lightmap] to be included in
the calculation of the [final texture appearance].

Each (pass/stage) of [blending] is [combined] in a cumulative manner, with the [color data] passed onto it by the [previous stage].

How that [data] combines together depends on the [values chosen] for the [Source Blends] and [Destination Blends] at [each stage].

Remember it's [numbers] that are being [mathematically combined together] that are ultimately interpreted as [colors].

A general rule is that any [Source Blend] other than [GL_ONE] (or [GL_SRC_ALPHA] where the [alpha channel] is entirely [white])
will cause the [Source] to become [darker].

6.2.3 Source Blend <srcBlend>

The following [values] are valid for the [Source Blend] part of the equation.

GL_ONE	This is the [value (1)]. When multiplied by the [Source], the [value] stays the same, the [value] of the [color information does not change].
GL_ZERO	This is the [value (0)]. When multiplied by the [Source], all [RGB data] in the [Source] becomes [Zero] (essentially [black]).
GL_DST_COLOR	This is the value of [color data] currently in the [Destination] ([frame buffer]). The [value] of that information [depends] on the information supplied by [previous stages].
GL_ONE_MINUS_DST_COLOR	This is nearly the same as [GL_DST_COLOR], except that the [value] for [each component color] is [inverted] by [subtracting it] from (1). (i.e.; R = 1.0 - DST.R, G = 1.0 - DST.G, B = 1.0 - DST.B, etc.)
GL_SRC_ALPHA	The [(*.tga) file] being used for the [Source data] must have an [alpha channel] in addition to its [RGB channels], for a total of [(4) channels]. The [alpha channel] is an (8)-bit (black/white) only channel.

	An [entirely white alpha channel] will NOT darken the [Source].
GL_ONE_MINUS_SRC_ALPHA	This is the same as [GL_SRC_ALPHA], except that the [value] in the [alpha channel] is [inverted] by [subtracting it] from (1). (i.e.; A=1.0 - SRC.A)

6.2.4 Destination Blend <dstBlend>
The following values are valid for the [Destination Blend] part of the equation.

GL_ONE	This is the [value (1)]. When [multiplied] by the [Destination], the [value] stays the same, the [value] of the [color information does not change].
GL_ZERO	This is the [value (0)]. When [multiplied] by the [Destination], all [RGB data] in the [Destination] becomes (0) (essentially [black]).
GL_SRC_COLOR	This is the [value] of [color data] currently in the [Source], which is the [texture] being manipulated here.
GL_ONE_MINUS_SRC_COLOR	This is the [value] of [color data] currently in [Source], but [subtracted] from (1) (i.e.; inverted).
GL_SRC_ALPHA	The [(*.tga) file] being used for the [Source data] must have an [alpha channel] in addition to its [RGB channels], for a total of (4) channels. The [alpha channel] is an (8)-bit (black/white) only channel. An entirely [white alpha channel] will NOT darken the [Source].
GL_ONE_MINUS_SRC_ALPHA	This is the same as [GL_SRC_ALPHA], except that the [value] in the [alpha channel] is [inverted] by [subtracting it] from (1). (i.e.; A=1.0 - SRC.A).

Doing the Math: The Final Result
The [product] of the [Source side of the equation] is [added] to the [product] of the [Destination side] of the [equation].

The [sum] is then [placed into the frame buffer] to become the [Destination information] for the [next stage].

Ultimately, the [equation] creates a [modified color value] that is used by [other functions] to define what happens in the [texture] when
it is [displayed in the game world].

6.2.5 Default Blend Function
If no [blendFunc] is specified, then [no blending will take place].

A warning is generated if [any stage] after the [first stage] does not have a [blendFunc] specified.

6.2.6 Technical Information/Limitations Regarding Blend Modes
The [Riva 128] graphics card supports ONLY the following [blend modes]:
GL_ONE, GL_ONE
GL_DST_COLOR, GL_ZERO
GL_ZERO, GL_SRC_COLOR
GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA
GL_ONE_MINUS_SRC_ALPHA, GL_SRC_ALPHA

Cards running in (16)-bit color cannot use any GL_DST_ALPHA blends.

6.3 rgbGen <func>
There are [(2) color sources] for ANY given [shader], the [texture file] and the [vertex colors].

[Output] at [any given time] will be [equal] to [TEXTURE multiplied by VERTEXCOLOR].

Most of the time, [VERTEXCOLOR] will [default to white], which is a normalized value of 1.0, so [output] will be [TEXTURE], this usually lands in the [Source side] of the [shader equation].

Sometimes, you do the [opposite] and use [TEXTURE = WHITE], but this is only commonly used when doing [specular lighting on entities] (i.e.; [shaders] that [level designers] will probably never create)

The [most common reason] to use [rgbGen] is to [pulsate] something.

This means that the [VERTEXCOLOR] will [oscillate] between [(2) values], and that [value] will be [multiplied], [darkening the texture].

If NO [rgbGen] is specified, either "identityLighting" or "identity" will be selected, depending on which [blend modes] are used.

Valid [<func> parameters] are:
(wave/identity/identityLighting/entity/oneMinusEntity/fromVertex/lightingDiffuse).

6.3.1 rgbGen identityLighting
[Colors] will be (1.0, 1.0, 1.0) if running without [overbright bits] (NT/Linux/windowed modes), or (0.5, 0.5, 0.5) if running with [overbright].

[Overbright] allows a [greater color range] at the expense of a [loss of precision].

[(Additive/blended) stages] will get this by default.

6.3.2 rgbGen identity
[Colors] are assumed to be all white (1.0,1.0,1.0).

All [filter stages] (lightmaps/etc.) will get this by default.

6.3.3 rgbGen wave <func> <base> <amp> <phase> <freq>
[Colors] are generated using the [specified waveform].

An [affected texture] with become (darker/lighter), but will NOT change hue, which stays constant.

Note that the [rgb values] for [color] will not go below (0/black) or above (1/white).

Valid [waveforms] are (sin/triangle/square/sawtooth/inversesawtooth).

<func>	[Wave forms] and their effects: Sin : [color] flows [smoothly] through changes Triangle : [color] changes at a [constant rate], and spends no appreciable time at (peaks/valleys) Square : [color alternates instantly] between its [(peak/valley) values] Sawtooth : With a [positive frequency value], the [color changes] at a [constant rate] to the [peak] then [instantly] drops to its [valley] value Inversesawtooth : An [inverse sawtooth wave] will reverse this, making the [ascent immediate], like a [square wave], and the decay fall off like a [triangle wave].
<base>	[Baseline value], the initial [RGB formula] of a [normalized color].
<amp>	[Amplitude], this is the [degree of change] from the [baseline value]. In some cases, you will want values [outside] the (0.0-1.0) range, but it will induce [clamping], holding at the (maximum/minimum) value for a [period of time] rather than [continuous change].
<phase>	See the explanation for [phase] under the [waveforms] heading of [Key Concepts].
<freq>	[Frequency], this is a value (NOT normalized) that indicates [peaks per second].

6.3.4 rgbGen entity
[Colors] are grabbed from the [entity's modulate field], this is used for things like [explosions].

Design Note: This [keyword] would probably not be used by a [level designer].

6.3.5 rgbGen oneMinusEntity
Colors are grabbed from (1.0) minus the [entity's modulate field].

Design Note: This [keyword] would probably not be used by a [level designer].

6.3.6 rgbGen Vertex
[Colors] are filled in [directly] by the data from the (map/model) files.

Design Note: [rgbGen vertex] should be used when you want the [RGB values] to be [computed] for a [static model] (i.e. mapobject) in the [game world] using [precomputed static lighting] from [Q3BSP].

This would be used on things like (gargoyles/portal frame/skulls/other decorative MD3s) put into the [Quake III Arena game world].

6.3.7 rgbGen oneMinusVertex
As [rgbGen vertex], but [inverted].

Design Note: This [keyword] would probably not be used by a [level designer]

6.3.8 rgbGen lightingDiffuse
[Colors] are [computed] using a [standard diffuse lighting equation].

It uses the [vertex normals] to [illuminate] the [object] correctly.

Design Note: [rgbGen lightingDiffuse] is used when you want the [RGB values] to be computed for a
[dynamic model] (i.e. non-map object) in the [game world] using regular [in-game lighting].

For example, you would specify on shaders for (items/characters/weapons/etc.)

6.4 AlphaGen <func>
The [alpha channel] can be specified like the [rgb channels].

If NOT specified, it defaults to (1.0).

6.4.1 AlphaGen portal
This [rendering stage keyword] is used in conjunction with the [surface parameter keyword "portal"].

The [function] accomplishes the "fade" that causes the [scene] in the [portal] to [fade from view].

Specifically, it means "Generate alpha values based on the distance from the viewer to the portal."

Use [alphaGen portal] on the [last rendering pass].

6.5 tcGen <coordinate source>
Specifies how [texture coordinates] are [generated], and [where they come from].

Valid functions are (base/lightmap/environment).

<base>	[base texture coordinates] from the [original art]
<lightmap>	[lightmap texture coordinates]
<environment>	Make this object [environment mapped]

6.5.1 tcGen vector (<sx> <sy> <sz>) (<tx> <ty> <tz>)
New [texcoord generation] by [world projection].

This allows you to [project a texture onto a surface] in a [fixed way], regardless of its [orientation].

(S) coordinates correspond to the "x" coordinates on the [texture] itself.
(T) coordinates correspond to the "y" coordinates on the [texture] itself.

The measurements are in [game units].

Example: tcGen vector (0.01 0 0) (0 0.01 0)
This would project a texture that repeats every (100) units across the (X/Y) plane.

6.6 tcMod <func> < ... >
Specifies how [texture coordinates] are [modified] AFTER they are generated.

The valid [functions] for [tcMod] are (rotate/scale/scroll/stretch/transform).

[Transform] is a function generally reserved for use by [programmers] who suggest that [designers]
leave it alone.

When using multiple [tcMod functions] during a [stage], place the [scroll command] LAST in order, because
it performs a [modulate operation] to save precision, and that can disturb other operations.

[Texture coordinates] are [modified] in the [order] in which [tcMods] are [specified].

In other words, if you see:
tcMod scale 0.5 0.5
tcMod scroll 1 1

Then, the [texture coordinates] will be [scaled], THEN [scrolled].

6.6.1 tcMod rotate <degrees per per second>
This [keyword] causes the [texture coordinates] to [rotate].

The [value] is [expressed] in [degrees rotated each second].

A [positive value] means [clockwise rotation].
A [negative value] means [counterclockwise rotation].

For example, [tcMod rotate 5] would rotate texture coordinates (5) degrees
each second in a [clockwise direction].

The [texture] rotates around the [center point] of the [texture map], so you are [rotating a texture] with a [single repetition], be careful to [center it on the brush], unless [off-center rotation] is [desired].

6.6.2 tcMod scale <sScale> <tScale>

[Resizes (enlarges/shrinks)] the [texture coordinates] by [multiplying them] against the given factors of <sScale> and <tScale>.

The values (s) and (t) conform to the (x) and (y) values respectively, as they are found in the [original texture (*.tga) file].

The values for (sScale/tScale) are NOT normalized.

This means that a [value] greater than (1.0) will [increase] the [size of the texture].

A [positive value] less than (1) will [reduce the texture] to a [fraction] of its [size], and cause it to [repeat] within the same area as the [original texture]

(Note: see [clampTexCoords] for ways to control this).

Example: [tcMod scale 0.5 2] would cause the [texture] to repeat (2) times along its width, but expand to (2) times its height, in which case, (1/2) of the texture would be seen in the same area as the original.

6.6.3 tcMod scroll <sSpeed> <tSpeed>

Scrolls the [texture coordinates] with the given speeds.

The values "s" and "t" conform to the "x" and "y" values (respectively), as they are found in the [original texture (*.tga) file], the [scroll speed] is measured in "textures" per second.

A "texture" is the [dimension] of the [texture] being [modified] and includes [any previous shader modifications] to the original [(*.tga) file].

A negative "s" value would [scroll the texture to the left].
A negative "t" value would [scroll the texture down].

Example: [tcMod scroll 0.5 -0.5] moves the texture (down + right), relative to the [(*.tga) file]'s original coordinates, at the rate of a [half texture] each second of travel.

This should be the LAST [tcMod] in a stage, otherwise there may be (popping/snapping) visual effects in some shaders.

6.6.4 tcMod stretch <func> <base> <amplitude> <phase> <frequency>

[Stretches the texture coordinates] with the given [function].

[Stretching] is defined as stretching the [texture coordinate away] from the [center] of the [polygon], and then [compressing it] towards the [center] of the [polygon].

func	[Sin]	The [texture expands smoothly] to its [peak dimension] and then [shrinks smoothly] to its [valley dimension] in a flowing manner
	[Triangle]	The [textures stretch at a constant rate] and spend [no appreciable time] at the (peak/valley) points
	[Square]	The [texture] is shown at its [peak] for the [duration] of the [frequency], and then at its [valley] for the [duration] of the [frequency]
	[Sawtooth]	The [texture stretches like a triangle wave] until it reaches a [peak], then [instantly drops] to the [valley], as in a [square wave]
	[Inversesawtooth]	This is the [reverse] of the [sawtooth wave]
base	A [base value] of (1), is the [original dimension] of the [texture] when it reaches the [stretch stage].	

	Inserting other (positive/negative) values in this variable will produce [unknown effects].
amplitude	This is the [measurement] of [distance] the [texture] will [stretch] from the [base size]. It is [measured], like scroll, in [textures]. A value of (1) here will (2x) the size of the texture at its peak.
phase	See the explanation for [phase] under the [deform vertexes] keyword.
frequency	this is wave peaks per second.

6.6.5 tcMod <transform> <m00> <m01> <m10> <m11> <t0> <t1>
Transforms each texture coordinate as follows:
S' = s * m00 + t * m10 + t0
T' = t * m01 + s * m11 + t1

This is for use by programmers.

6.6.6 tcMod turb <base> <amplitude> <phase> <freq>
Applies [turbulence] to the [texture coordinate].

[Turbulence] is a (back/forth) (churning + swirling) effect on the [texture].

The parameters for this shader are defined as follows:

base	Currently [undefined].
amplitude	This is essentially the [intensity] of the [disturbance/twisting/squiggling] of the [texture].
phase	See the [explanation] for phase under the [deform vertexes keyword].
freq	[Frequency], this value is expressed as (repetitions/cycles) of the wave per second. A value of (1) would cycle (1) time per second. A value of (10) would cycle (10) times per second. A value of (0.1) would cycle once every (10) seconds.

6.7 depthFunc <func>
This controls the [depth comparison function] used while [rendering].

The default is "lequal" (less than, or equal to) where [any surface] that is at the [same depth] or [closer] of an [existing surface] is [drawn].

This is used for [textures] with (transparency/translucency).

Under some circumstances, you may wish to use "equal", e.g. for lightmapped grates that are [alpha tested], it is also used for [mirrors].

6.8 depthWrite
By default, writes to the depth buffer when depthFunc passes will happen for opaque surfaces and not for translucent surfaces. Blended surfaces can have the depth writes forced with this function.

6.9 Detail
This feature was not used in [Quake III Arena] maps, but should still function.

Designates this [stage] as a [detail texture stage], which means that if the c_var [r_detailtextures], is set to (0) then [this stage will be ignored], (detail will not be displayed).

This [keyword] by itself, does not affect [rendering] at all.

If you DO put in a [detail texture], it has to [conform] to [very specific rules].

Specifically, the [blendFunc]:
[blendFunc GL_DST_COLOR GL_SRC_COLOR]

This is ALSO the simple blend function: [blendfunc filter]

And the [average intensity] of the [detail texture itself] must be around (127).

[Detail] is used to [blend fine pixel detail] back into a [base texture] whose [scale] has been [increased significantly].

When [detail] is [written] into a [set of stage instructions], it [allows the stage] to be [disabled] by the c_var console command setting [r_detailtextures 0].

A [texture] whose [scale] has been increased beyond a (1:1) ratio tends to NOT have [very high frequency content].

In other words, [(1) texel] can cover a LOT of real estate.

[Frequency] is also known as "detail", lack of [detail] can appear [acceptable] if the player never has the opportunity to see the [texture] at [close range].

But seen close up, such [textures] look [glaringly wrong] within the [sharp detail] of the [Quake III Arena] environment.

A [detail texture] solves this problem, by taking a noisy "detail" pattern ... a [tiling texture] that appears to have a [great deal] of [surface roughness], and [applying it] to the [base texture] at a [very densely packed scale] ... that is, [reduced from its normal size].

This is done [programmatically] in the [shader], and does NOT require [modification] of the [base texture].

Note, that if the [detail texture] is the [same (size/scale)] as the [base texture], that you may as well just [add the detail directly to the base texture].

The theory is that the [detail texture's scale] will be [so high] compared to the [base texture] (e.g.; (9) detail texels fitting into (1) base texel), that it is [literally impossible] to fit that detail into the [base texture] directly.

For this to work, the rules are as follows:

A	The [lightmap] must be [rendered first], this is because the [subsequent detail texture] will be [modifying the lightmap] in the [framebuffer] directly.
B	The [detail texture] must be [rendered next], since it [modifies the lightmap] in the [framebuffer]
C	The [base texture] must be rendered last
D	The detail texture MUST have a [mean intensity] around (127-129). If it does NOT, then it will [modify] the [displayed texture's] perceived [brightness] in the [game world]
E	The [detail shader stage] MUST have the "detail" keyword or it will not be disabled if the user uses the [r_detailtextures 0] setting
F	The [detail stage] MUST use [blendFunc GL_DST_COLOR GL_SRC_COLOR]. Any other [BlendFunc] will cause [mismatches in brightness] between (detail/non-detail) views.
G	The [detail stage] should [scale] its [textures] by [some amount], usually between (3-12) using [tcMod] to control [density]. This roughly corresponds to [coarseness]. A very large number, such as (12), will give [very fine detail], however that [detail] will disappear VERY quickly as the viewer moves away from the wall, since it will be [mipmapped away]. A very small number, e.g. (3), gives [diminishing returns] since not enough is brought in when the user gets very close. I'm currently using values between (6-9.5). You should use [non-integral numbers] as much as possible to [avoid seeing repeating patterns].
H	[detail textures] add (1) pass of [overdraw], so there is a [definite performance hit].
I	[detail textures] can be [shared], so [designers] may wish to define only a very small handful of [detail textures] for [common surfaces] such as rocks, etc.

An example (non-existent) [detail shader] is as follows:

Example: Texture with Detail

```
textures/bwhtest/foo
{
    // draw the lightmap first
    {
```

```
        map $lightmap
        rgbGen identity
    }
    // modify the lightmap in the framebuffer by a highly compressed detail texture
    {
        map textures/details/detail01.tga
        blendFunc GL_DST_COLOR GL_SRC_COLOR
        // YOU MUST USE THIS!!
        detail
        // for the detail to be disabled, this must be present
        tcMod scale 9.1 9.2
    }
    // now slap on the base texture
    {
        map textures/castle/blocks11b.tga
        blendFunc filter
    }
}
```

6.10 alphaFunc <func>

Determines the [alpha test function] used when [rendering] this map.

Valid values are:

GT0	Greater than (0)
LT128	Less than (128)
GE128	Greater than or equal to (128)

This [function] is used when determining if a [pixel] should be [written to the framebuffer].

For example, if [GT0] is specified, the ONLY the portions of the texture map with corresponding [alpha values greater than zero], will be[written to the framebuffer].

By default [alpha testing] is [disabled].

Both [alpha testing] and [normal alpha blending] can be used to get [textures] that have [see-through parts].

The difference is that [alphaFunc] is an [all-or-nothing test], while [blending] smoothly blends between (opaque/translucent) at pixel edges.

[Alpha test] can also be used with [depthwrite], allowing [other effects] to be [conditionally layered] on top of just the [opaque pixels] by setting [depthFunc] to equal.

7. Notes on Alpha Channels

To use some [blend modes] of [alphaFunc], you must add an [alpha channel] to your [texture files].

[Photoshop] can do this.
[Paintshop Pro] has the ability to make an [alpha channel], but cannot work directly into it.

In [Photoshop], you want to set the type to [Mask].

[Black] has a value of (255).
[White] has a value of (0).

The [darkness] of a pixel's [alpha value] determines the [transparency] of the [corresponding RGB value] in the [game world].

[Darker] = [more transparent].

Care must be taken when [reworking textures] with [alpha channels].

[Textures] without [alpha channels] are saved as (24)-bit images, while [textures] WITH [alpha channels] are saved as (32)-bit.

If you save them out as (24)-bit, the [alpha channel] is [erased].

Note: [Adobe Photoshop] will [prompt you] to save as (32/24/16) bit, so choose wisely.

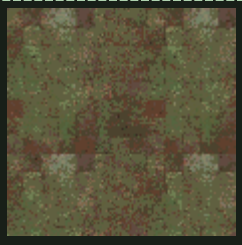
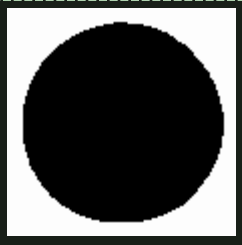
If you [save a texture] as (32)-bit and you don't actually have anything in the [alpha channel], [Quake III Arena] may still be forced to use a [lower quality texture format] when in (16)-bit rendering, than if you had saved it as (24)-bit.

To [create a texture] that has "open" areas, make those areas [black] in the [alpha channel] and make the areas that are to be opaque [white].

Using [gray shades] can create [varying degrees] of (opacity/transparency).

Example: An opaque texture with see-through holes knocked in it.

```
textures/base_floor/pjgrate1
{
    surfaceparm metalsteps
    cull none
    // A GRATE OR GRILL THAT CAN BE SEEN FROM BOTH SIDES
    {
        map textures/base_floor/pjgrate1.tga
        blendFunc GL_SRC_ALPHA GL_ONE_MINUS_SRC_ALPHA
        alphaFunc GT0
        depthWrite
        rgbGen identity
    }
    {
        map $lightmap
        rgbGen identity
        blendFunc GL_DST_COLOR GL_ZERO
        depthFunc equal
    }
}
```

1A	1B	1C	1D	1E
				
pentagram.tga	Alpha channel of pentagram.tga by using GL_SRC_ALPHA	greenfloor.tga	Inverted alpha channel of pentagram.tga inverted by using GL_ONE_MINUS_SRC_ALPHA	Greenfloor with pentagram merged into it.

Start with a [(*.tga) file] image.

In this case, a [pentagram] on a [plain white field] (figure 1A).

The [color] of the [field] surrrounding the [image] to be [merged] is not relevant to this process, although having a [hard-edged break] between the [image] to be [isolated] and the [field] makes the [mask making process] easier.

Make an [alpha channel].

The [area] of the [image] to be [merged] with [another image] is [masked off in white].

The area to be [masked out] (not used) is [pure black] (figure 1B).

The [image] to be [merged into], is [greenfloor.tga] (figure 1C).

Make a [qer_editorimage] of [greenfloor.tga].

This is placed in the [frame buffer] as the [map image] for the [texture].

By using [GL_SRC_ALPHA] as the [source part] of the [blend equation], the [shader] adds in only the [non-black parts of the pentagram].

Using [GL_MINUS_ONE_SRC_ALPHA], the [shader] inverts the pentagram`'s [alpha channel], and adds in only the [non-black] parts of the [green floor].

In a like manner, the [alpha channel] can be used to [blend] the [textures] more evenly.

A simple experiment involves using a [linear gradiant] in the [alpha channel] (white to black) and [merging two textures] so they appear to
[cross fade] into each other.

A [more complicated experiment] would be to take the [pentagram] in the [first example] and give it an [aliased edge] so that the [pentagram] appeared to (fade/blend) into the floor.

[Quake III Arena] Shader Manual

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