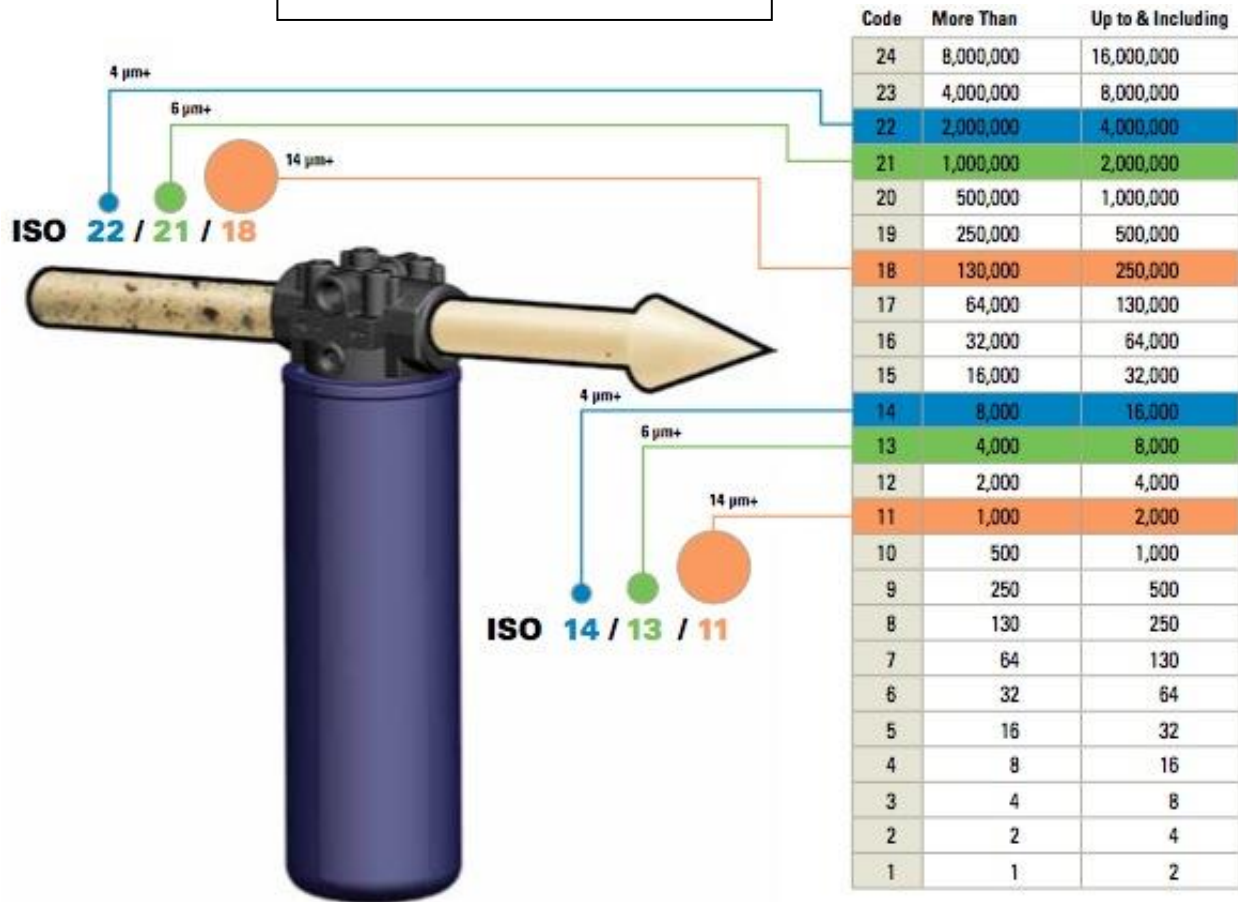


ISO Diesel Fuel Cleanliness Chart



In today's world, defining how clean or dirty fuel is, is critically important and as such, fuel cleanliness levels are now measured and reported according to the ISO Cleanliness Code 4406:1999. The International Organization for Standardization (ISO) created the cleanliness code ISO4406:1999 to quantify particulate contamination levels per milliliter of fluid at three sizes: 4μ, 6μ, 14μ. Microns

Scale Number	Particles per ml. More Than	Particles per ml. Less or Equal
22	2,000,000	4,000,000
21	1,000,000	2,000,000
20	500,000	1,000,000
19	250,000	500,000
18	130,000	250,000

17	64,000	130,000
16	32,000	64,000
15	16,000	32,000
14	8,000	16,000
13	4,000	8,000
12	2,000	4,000
11	1,000	2,000
10	500	1000
9	250	500
8	130	250
7	64	130
6	32	64

## Fuel Cleanliness Vs. Engine Technology

Fuel cleanliness levels using the ISO4406:1999 method were officially documented as a global standard only as recently as 1998 with the development of the Worldwide Fuels Charter (WWFC). Since its inception, the charter has established a minimum cleanliness level for each of the diesel fuels under various available categories around the world.

### WWFC Diesel Category Fuel Cleanliness Standards

Diesel Category	Cleanliness Level
Tier 1	10 mg/kg
Tier 2	ISO 18/16/13
Tier 3	ISO 18/16/13
Tier 4	ISO 14/13/11

Most mainstream engine OEM's now subscribe to these standards. Interestingly, however, and somewhat troubling to note, is that fuel cleanliness levels being specified by engine OEM's and the WWFC have not changed since their inception in 1998, despite the enormous advances in fuel injection technology. This relationship is best represented in the previous table that identifies the advances in fuel injection systems and clearly highlights how OEM's and the WWFC have not responded to reduce fuel cleanliness in accordance with advancements in technology.

### Diesel Fuel Injection – Advancing Technologies & Cleanliness Levels

Injection	Pressure	Viscosity	Clearances	Cleanliness
EUI	16,000 psi	1-4 cSt	5-8 $\mu$ m	18/16/13
HPCR	36,000 psi	1-4 cSt	1-4 $\mu$ m	14/13/11

**This table identifies that over time, fuel injector critical clearances have halved and fuel pressures have doubled, yet the level of fuel cleanliness being specified has not altered in accordance with such advancements. In fact, the same cleanliness levels specified in 2000 are still being used today despite these magnificent technological advancements.**

Leading fuel injector manufacturers around the world have clearly identified and communicated that they require UCD fuels with fuel cleanliness levels as low as ISO12/9/6 to maintain ultimate performance and reliability. It is here where we see an enormous mismatch in what the fuel injection OEM desires as a fuel cleanliness level, to what the engine OEM's and the WWFC are advising the industry. The following table identifies the discrepancies in fuel cleanliness levels.

### Diesel Cleanliness Levels

Company	Specified ISO Cleanliness Level
World Wide Fuel Charter	18/16/13
Engine OEM's	14/13/11
Fuel Injector OEM	12/9/6

**Owners and operators of diesel engines should take note that the cleanliness levels required by the fuel injector OEM's are 64x cleaner than what the industry is being advised as an acceptable standard for engines to be fueled with. This is a critical point when considering contamination control solutions for diesel fuel systems.**

