1.0 INTRODUCTION :

As the globalization continues and the earth's natural processes transform local problems into international issues a number of environmental problems are now affecting the entire world. In view of this the concern about the environment is not confined to local or national level but the countries all over the world are focussing attention under new concept of 'global environmental problems'. These global problems, with far-reaching environmental threats, include ozone layer depletion, global warming, acid rain, rain forest destruction etc. Among these the issue of Ozone layer depletion is well up on the International Scene since last decade and will continue for couple of decades.

1.1 Ozone layer and Depletion Effects :

Ozone is composed of three atoms of oxygen and is a bluish gas that is harmful to breath. Nearly 90% of the Earth's ozone is in the stratosphere which forms ozone layer. Ozone between the Earth's surface and outer space is termed as column ozone which is measured in Dobson unit (DU) by Dobson spectrophotometer. 1 DU is defined to be 0.01 mm thickness at STP. To further explain, If 100 DU of ozone is brought to the Earth's surface, it would form a layer 1mm thick.

The region of the stratosphere containing the bulk of atmospheric ozone, i.e. ozone layer, lies approximately 15-40 Kilometers above the Earth's surface. This layer protects life on the earth from the harmful ultraviolet rays (UV-b). Depletion of this layer by ozone depleting substances (ODS) leads to higher UV-b levels which in turn causes devastating health effects and damage to the environment. This stratospheric ozone is generated and destroyed through natural cycle but some man-made chemicals like chlorofluoro carbons (CFCs), Halons and other ozone depleting substances used in air conditioners, coolants, foaming, fire extinguishers, solvents etc. accelerate the ozone destruction process. The probable effects of ozone layer depletion are noted as follows :

- Increased UV-b radiation reaching earth's surface.
- Damage to materials, paint, plastics, rubber etc.
- Damage to biological links in human food chain.
- Crop and forest damage.
- Rise in incidence of skin cancer.
- Human health effects such as respiratory illness and heart Problems

- Effects on terrestrial ecosystems with reduced crop yields and stunted plant growth.
- Effects on aquatic life such as lower fish harvests and less ocean plankton etc.
- Increased incidence of cataracts and blindness.
- Suppression of body immunity resulting in increase in infectious disease, less effective vaccination.
- Photochemical formation of tropospheric ozone which contributes to global warming.
- Accumulation of tropospheric ozone and acid aerosols causing worsening air pollution and acid rain.

1.2 UV-radiations :

The ultraviolet radiation is a portion of the electromagnetic radiation emitted by the sun acres a wide spectrum. The radiation above wavelenght of 400 nm is a visible spectrum. The UV portion of radiation includes all radiation from 15 to 390 nm, i.e. shorter than visible light. The UV is commonly split into three bonds viz UV-a, UV-b and UV-c. The **UV-a** band has wave length from 320-400 nm and is not absorbed by ozone. The **UV-b** band has a wave length from 280 to 320 nm and it is this band of UV-radiation which causes several harmful effects. The ozone layer absorbs most of the portion of this UV-b in order to protect the Earth. The **UV-c** radiation has a wavelength shorter than 280 mm and is exramely dangerous but it is completely absorbed by ozone and normal oxygen.

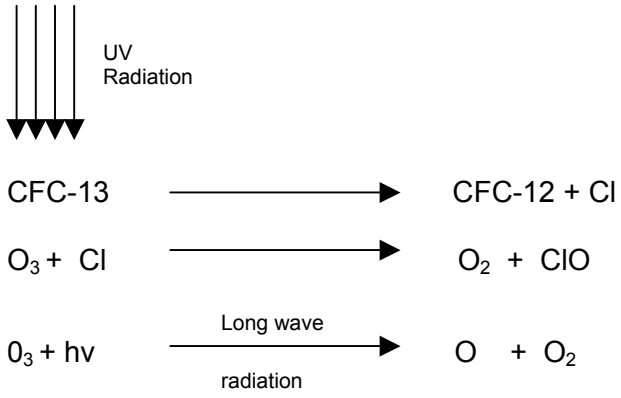
The UV-radiation are also used for beneficial things like for treatment of Rickets in individuals sensitive to vitamin 'D' preparations. In conjunction with chemicals they are used in treating skin diseases viz. pity riasis, rosea, acne, sterilization of air in hospitals, in research applications etc.

1.3 Ozone Depletion Chemistry :

The classes of Ozone Depleting Substances (ODS) includes Halons, Chlorofluoro carbons (CFCs) Hydrochlorofluorocarbons (HCFCs) Hydrobromofluorocarbons (HBFCs), Methyl bromide, Carbon tetra chloride (CTC) and methyl chlorofom. These compounds are wholly man-made combination of carbon, hydrogen, fluorine and chlorine. These are highly stable in the stratosphere and unreactive chemically so once they release into the atmosphere they remain there for a long time, i.e. up to 100 to 200 years, before being destroyed. These, however, degrade under intense ultraviolet light in the stratosphere and during break down procedure they release chlorine or

bromine atom which deplete ozone. The ODS have been broadly classified as class I and class II substances. A group of chemicals with an ozone depletion potential (ODP) of 0.2 or above have been put under class I substances and chemicals having ODP of less than 0.2 are termed as class II substances. All the HCFCs are class II substances and rest of the aforementioned chemicals are class I substances.

The ozone depleting substances, present in the atmosphere, are broken down by solar radiation in the stratosphere releasing chlorine and bromine atoms which initiate a destructive chain reaction resulting in breaking of ozone gas in to oxygen and chlorine monoxide. This breaking of ozone gas results in reduction of atmospheric ozone. It has been established that a single chlorine radical can break 1 million molecules of ozone. The breakdown of ozone goes as follows :



To cope up with this depletion problem their substitutes are being developed, composed basically of fluorine, hydrogen and carbon but no chlorine, called HFCs. These substitutes do not damage the ozone layer but may contribute to global warming. The ozone depletion potential (ODP) and global warming potential (GWP) of principal ozone depleting substances (ODS) is given at page no. 7and 13.

1.4 Status of O.D.S. in India :

The production and consumption of ODS is being phased out the world over and India is also committed to work in this direction and, being a signatory to the Montreal Protocol, has taken steps to comply the Protocol terms. The data on production and consumption of ODS are tabulated at page 6. The quantity shown in the table is presented in ODP tons, i.e. quantity of ODS consumed or produced multiplied by O.D.P. of that particular substance. Production has been defined under the Protocol as production minus the quantity destroyed minus the quantity entirely used as feed stock in the manufacture of other chemicals. The consumption is defined as production plus imports minus exports of controlled substances. Figures of production are shown for each

year and, hence, if the feedstock use is from a carry-over stock, the feedstock figure may exceed the production figure of that year. The production could be negative in such cases, as is shown in the table ahead.

1.5 Status of O.D.S. in Madhya Pradesh State :

The Emergency Response Centre at M.P. Pollution Control Board has also taken initiatives and necessary steps to join hands and contribute to resolve the this global issue of phasing out of O.D.S. An updated status report regarding trend in production and consumption of O.D.S. in various industries and other installations in Madhya Pradesh State has been prepared to decide further strategy in the matter. Awareness programmes are also taken up in the State for general public to make them aware about the ultimate hazards caused by O.D.S. and to promote use of non ozone depleting substances and technologies. Necessary guidance to the target groups is also provided on "query response" basis.

None of the industries in the State is Manufacturing O.D.S., however, some of the units are using O.D.S. for various applications but the quantum is very low. All the industries and relevant institutions have been made aware about the phasing out schedule. The State inventory is given at page 6.

1.6 Global Development and Treaties :

In 1970 it was found that emission of these CFCs is the main cause of stratospheric ozone depletion. In 1974, it was established that CFCs are responsible for the damage of stratoshperic ozone layer and the same fact has been reported in the subsequent studies. Because of this damaging effect and serious consequences of the use of CFCs international action has been taken in this regard. In 1985, Vienna convention was held for the protection of ozone layer which covered only research and exchange information. This was followed by Montreal Protocol in 1987 which was signed by 82 countries. The tally of signatory countries has now gone up to 160 and India is also a party to it.

This protocol has set the limit on the production of ozone depleting substances (ODS) with aim to content the further damage of ozone layer. This Protocol , developed under the management of United Nations Environment Programme (UNEP) in 1987, came into force on 1st January 1989 and defines the measures that parties (countries) must take to limit production and consumption of the controlled substances, mainly five CFCs and three halons. Later, it was assumed that Montreal protocol would not control the problem adequately and therefore it was followed by amendments agreed in London in 1991 and in Copenhagen in 1992 which states that CFCs be phased out completely by the year 1996 in the industrialized countries. This was followed by further amendments agreed in Vienna in1995, Montreal in 1997 and in Beijing in January 2000. All these aim to reduce and eventually eliminate the emission of man-made ozone-depleting substances. It is assumed that ongoing efforts will result in recovery of the ozone layer in about 50 years from now.

1.7 Exemption on use of O.D.S. :

The decision ix / 17, taken in the 9th meeting of the parties to the Montreal Protocol on substances that deplete ozone layer, states about the essential use exemption for laboratory and analytical uses of ozone depleting substances. The essential use exemption for laboratory and analytical uses of controlled substances shall continue to exclude the production of products made with or containing such substances. All the institutions/laboratories are however required to maintain the stock book on utilization of ODS properly to ensure judicious use.

1.8 India's commitment to Montreal Protocol :

Depletion of ozone layer has attracted global attention due to its harmful effects on world community. Findings of scientific community and foresight of Governments led to the signing of Montreal Protocol in September 1987 to which India is also a signatory. India is also committed to phase out Ozone Depleting Substances within the time frame decided under protocol. Our recognition is already there at International scene and the efforts have been hailed by international authorities a number of times. In this series the *U.S. Environmental Protection Agency has awarded its 1998 stratospheric ozone protection award to the Halon Alternative Option Committee (HAOC), India in Washington in October 1998.* Various promotional activities have started showing results and it has been estimated that the halon consumption has been reduced by 75 per cent in the past three to five years in India. The Government of India has also come out with a separate set of Rules under title **Ozone Depleting Substances (Regulation and Control) Rules, 2000** in order to deal with the matter more effectively to achieve the aims.

Production and consumption of O.D.S. in India

O.D.S.		1991	'92	'93	'94	'95	'96	'97	'98
CFCs (11,12,113,114,115)	P	--	6097	11439	16646	21780	22460	23658	20013
	C	--	4501	5277	6387	6402	6937	6703	--
Halon (1211,1301,2402)	P	--	348	261	396	241	305	321	--
	C	--	1253	216	610	478	630	237	--
CTC	P	--	1958	(-)1036	8433	(-)21778	19787	7876	--
Methyl Chloroform	P	--	48	56	00	00	00	00	--
HCFC	P	--	206	265	266	314	280	00	--
Methyl Bromide	P	74	--	--	--	--	--	--	--

(Unit : O.D.P. tons)

Consumption of O.D.S. in Madhya Pradesh State

O.D.S.	**1994-95**	**1995-96**	**1996-97**	**1997-98**
CFC-11	--	--	250	264
CFC-12	189	249.2	204	95
CFC-22	517	1193	3047	3832
CCl_4	18690	10777	6614	5039
CFC-113	1296	--	--	--

Unit : Kg./yr.

2.0 OZONE DEPLETING SUBSTANCES

The class of Ozone Depleting Substances (ODS) includes Halons, Chlorofluoro carbons (CFCs) Hydrochlorofluorocarbons (HCFCs) Hydrobromofluorocarbons (HBFCs), Methyl bromide, Carbon tetra chloride (CTC) and methyl chlorofom. These compounds are wholly man-made combination of carbon, hydrogen, fluorine and chlorine. These are highly stable in the stratosphere and unreactive chemically and have been broadly classified as class I and class II substances. A group of chemicals with an ozone depletion potential (ODP) of 0.2 or above have been put under class I substances and chemicals having ODP of less than 0.2 are termed as class II substances. All the HCFCs are class II substances and rest of the aforementioned chemicals are class I substances. The Ozone Depleting Substances are tabulated as follows :

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
1.	CFC-11	Trichlorofluoromethane ($CFCl_3$)	I	1.0
2.	CFC-12	Dichlorodifluoromethane (CF_2Cl_2)	I	1.0
3.	CFC-113	Trichlorotrifluoroethane ($C_2F_3Cl_3$)	I	0.8
4.	CFC-114	Dichlorotetrafluoroethane ($C_2F_4Cl_2$)	I	1.0
5.	CFC-115	Chloropentafluoroethane (C_2F_5Cl)	I	0.6
6.	Halon-1211	Bromochlorodifluoromethane (CF_2BrCl)	II	3.0
7.	Halon-1301	Bromotrifluoromethane (CF_3Br)	II	10.0
8.	Halon-2402	Dibromotetrafluoroethane ($C_2F_4Br_2$)	II	6.0
9.	CFC-13	Chlorotrifluoromethane (CF_3Cl)	III	1.0
10.	CFC-111	pentachlorofluoroethane (C_2FCl_5)	III	1.0
11.	CFC-112	Tetrachlordifluoroethane ($C_2F_2Cl_4$)	III	1.0

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
12.	CFC-211	Heptachlorofluoropropane (C_3FCl_7)	III	1.0
13.	CFC-212	Hexachlorodifluoropropane ($C_3F_2Cl_6$)	III	1.0
14.	CFC-213	Pentachlorotrifluoropropane ($C_3F_3Cl_5$)	III	1.0
15.	CFC-214	Tetrachlorotetrafluoro propane ($C_3F_4Cl_4$)	III	1.0
16.	CFC-215	Trichloropentafluoropropane ($C_3F_5Cl_3$)	III	1.0
17.	CFC-216	Dichlorophexafluoropropane ($C_3F_6Cl_2$)	III	1.0
18.	CFC-217	Chloropheptafluropropane (C_3F_7Cl)	III	1.0
19.	Carbon tetra-chloride	Tetrachloromethane (CCl_4)	IV	1.1
20.	Methyl chlorof-orm	1,1,1-Trichloroethane ($C_2H_3Cl_3$)	V	0.1
21.	HCFC-21	Dichlorofluoromethane ($CHFCl_2$)	VI	0.04
22.	HCFC-22	Dichlorodifluoromethane (CHF_2Cl_2)	VI	0.055
23.	HCFC-31	Chlorofluoromethane (CH_2FCl)	VI	0.02
24.	HCFC-121	Tetrachlorodifluoroethane ($C_2HF_2Cl_4$)	VI	0.04
25.	HCFC-122	Trichlorodifluoroethane ($C_2HF_2Cl_3$)	VI	0.08
26.	HCFC-123	2,2-dichloro-1,1,1-trifl-uoroethane ($C_2HF_3Cl_2$)	VI	0.06

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
27.	HCFC-123a	1,2-dichloro-1,1,2-trifluoroethane ($CHCl_2CF_3$)	VI	0.02
28.	HCFC-124	2-Chloro-1,1,1,2-trifluoroethane (C_2HF_4Cl)	VI	0.04
29.	HCFC-124a	2-chloro-1,1,2,2-trifluoroethane ($CHFClCF_3$)	VI	0.022
30.	HCFC-131	Trichlorofluoroethane ($C_2H_2FCl_3$)	VI	0.05
31.	HCFC-132	Dichlorodifluoroethane ($C_2H_2F_2Cl_2$)	VI	0.05
32.	HCFC-133	Chlorotrifluoroethane ($C_2H_3F_3Cl$)	VI	0.06
33.	HCFC-141	Dichlorofluoroethane ($C_2H_3FCl_2$)	VI	0.07
34.	HCFC-141b	1,1-dichloro-1-fluoroehane (CH_3CFCl_2)	VI	0.11
35.	HCFC-142	Chlorodifluoroethane ($C_2H_3F_2Cl$)	VI	0.07
36.	HCFC-142-b	1-chloro-1,1-difluoroethane (CH_3CF_2Cl)	VI	0.065
37.	HCFC-151	Chlorofluoroethane (C_2H_4FCl)	VI	0.005
38.	HCFC-221	Hexachlorofluoropropane (C_3HFCl_6)	VI	0.07
39.	HCFC-222	Pentachlorodifluoropropane ($C_3HF_2Cl_5$)	VI	0.09
40.	HCFC-223	Tetrachlorotrifluoropropane ($C_3HF_3Cl_4$)	VI	0.08
41.	HCFC-224	Trichlorotetrafluoropropane ($C_2HF_4Cl_3$)	VI	0.09

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
42.	HCFC-225	Dichloropentafluoro-propane ($C_3HF_5Cl_2$)	VI	0.07
43.	HCFC-225ca	1,3-dichloro-1,2,2,2,3, 3-pentafluoropropane ($CF_3CF_2CHCl_2$)	VI	0.025
44.	HCFC-225cb	1-3-dichloro-1,2,2,2,3, 3-pentafluoropropane (CF_2ClCF_2CHClF)	VI	0.033
45.	HCFC-226	Chlorohexafluoropropane (C_2HF_6Cl)	VI	0.10
46.	HCFC-231	Pentachlorofluoropropane ($C_3H_2FCl_5$)	VI	0.09
47.	HCFC-232	Tetrachlorodifluoropropane ($C_3H_2F_2Cl_4$)	VI	0.10
48.	HCFC-233	Trichlorotrifluoropropane ($C_3H_2F_3Cl_3$)	VI	0.23
49.	HCFC-234	Dichlorotetrafluoropropane ($C_3H_2F_4Cl_2$)	VI	0.28
50.	HCFC-235	Chloropentafluoropropane ($C_3H_2F_5Cl$)	VI	0.52
51.	HCFC-241	Tetrachlorofluoropropane ($C_3H_3FCl_4$)	VI	0.09
52.	HCFC-242	Trichlorodifluoropropane ($C_3H_3F_2Cl_3$)	VI	0.13
53.	HCFC-243	Dichlorotrifluoropropane ($C_3H_3F_3Cl_2$)	VI	0.12
54.	HCFC-244	Chlorotetrafluoropropane ($C_3H_3F_4Cl$)	VI	0.14
55.	HCFC-251	Trichlorofluoropropane ($C_3H_4FCl_3$)	VI	0.01
56.	HCFC-252	Dichlorodifluoropropane	VI	0.04

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
		($C_3H_4F_2Cl_2$)		
57.	HCFC-253	Chlorotrifluropropane ($C_3H_4F_3Cl$)	VI	0.03
58.	HCFC-261	Dichlorofluoropropane ($C_3H_5FCl_2$)	VI	0.02
59.	HCFC-262	Chlorodifluoropropane ($C_3H_5F_2Cl$)	VI	0.02
60.	HCFC-271	Chlorofluoropropane (C_3H_6FCl)	VI	0.03
61.	HBFC-21B2	Dibromofluoromethane ($CHFBr_2$)	VII	1.0
62.	HBFC-22B1	Bromodifluoromethane (CHF_2Br)	VII	0.74
63.		Bromofluoromethane (CH_2FBr)	VII	0.73
64.		Tetrabromofluoroethane (C_2HFBr_4)	VII	0.8
65.		Tribromodifluoroethane ($C_2HF_2Br_3$)	VII	1.8
66.	HBFC-123B2 HBFC-123aB2	Dibromotrifluoroethane ($C_2HF_3Br_2$)	VII	1.6
67.	HBFC-124B1	Brometetrafluoroethane (C_2HF_4Br)	VII	1.2
68.		Tribromofluoroethane ($C_2H_2FBr_3$)	VII	1.1
69.		Dibromodifluoroethane ($C_2H_2F_2Br_2$)	VII	1.5
70.		Bromotrifluoroethane ($C_2H_2F_3Br$)	VII	1.6
71.		Dibromofluoroethane	VII	1.7

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
	($C_2H_3FBr_2$)			
72.	HBFC-124B1	Bromodifluoroethane ($C_2H_3F_2Br$)	VII	1.1
73.	HBFC-124B1	Bromofluoroethane (C_2H_4FBr)	VII	0.1
74.		Haxabromofluoropropane (C_3HFB_6)	VII	1.5
75.		Pentabromodifluoropropane ($C_3HF_2Br_5$)	VII	1.9
76.		Tetrabromofluoropropane ($C_3HF_3Br_4$)	VII	1.8
77.		Tribromotetrafluoroproapne ($C_3HF_4Br_3$)	VII	2.2
78.		Dibromopentafluoropropane ($C_3HF_5Br_2$)	VII	2.0
79.		Bromohexafluoropropane (C_3HF_6Br)	VII	3.3
80.		Pentabromofluoropropane ($C_3H_2FBr_5$)	VII	1.9
81.		Tetrabromodifluoropropane ($C_3H_2F_2Br_4$)	VII	2.1
82.		Tribromotrifluoropropane ($C_3H_2F_3Br_3$)	VII	5.6
83.		Dibromotetrafluropropane ($C_3H_2F_4Br_2$)	VII	7.5
84.		Bromopentafluoropropane ($C_3H_2F_5Br$)	VII	1.4
85.		Tetrabromofluoropropane ($C_3H_3FBr_4$)	VII	1.9
86.		Tribromodifluoropropane ($C_3H_3F_2Br_3$)	VII	3.1
87.		Dibromotrifluoropropane	VII	2.5

S.N.	O.D.S.	Chemical Composition	Group	O.D.P.
		($C_3H_3F_3Br_2$)		
88.		Bromotetrafluoropropane ($C_3H_3F_4Br$)	VII	4.4
89.		Tribromofluoropropane ($C_3H_4FBr_3$)	VII	0.3
90.		Dibromodifluoropropane ($C_3H_4F_2Br_2$)	VII	1.0
91.		Bromotrifluoropropane ($C_3H_4F_3Br$)	VII	0.8
92.		Dibromofluoropropane ($C_3H_5FBr_2$)	VII	0.4
93.		Bromodifluoropropane ($C_3H_5F_2Br$)	VII	0.8
94.		Bromofluoropropane (C_3H_6FBr)	VII	0.7
95.	Methyl bromide	(CH_3Br)	VIII	0.6

3.0 O.D.P. and G.W.P. of ODS and non ODS

The ozone depleting potential (ODP) is a number that refers to the amount of ozone depletion caused by a substance or it is a ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined to be 0.1.

The Global warming potential (GWP) is a number that refers to the amount of global warming caused by a substance or it is a ratio of the warming caused by a substance to the warming caused by a similar mass of carbondioxide. Thus, the GWP of CO_2 is defined to be 1.0. The ODP and GWP of some ozone depleting and non ozone depleting substances are given below :

G.W.P. of Non Ozone Depleting Substances :

Chemical	Atmospheric lifetime	GWP	Use
HFC-23	264	11,700	Byproduct of HCFC-22, used in very low temperature refrigeration, blend component in fire suppression, and plasma etching and cleaning in semiconductor production.
HFC-32	5.6	650	Blend component of numerous refrigerants.
HFC-41	3.7	150	Not in use today.
HFC-43-10mee	17.1	1,300	Cleaning solvent
HFC-125	32.6	2,800	Blend component of numerous refrigerants and a fire suppressant
HFC-134	10.6	1,000	Not in use today.
HFC-134a	14.6	1,300	Most widely used refrigerant, blend component of other refrigerants, propellant in metered-dose inhalers and aerosols and foam blowing agent
HFC-152a	1.5	140	Blend component of several refrigerant blends.
HFC-143	3.8	300	Not in use today,
HFC-143a	48.3	3,800	Refrigerant blend
HFC-227ea	36.5	2,900	Fire suppressant and propellant for metered-dose inhalers.
HFC-236fa	209	6,300	Refrigerant and fire suppressant
HFC-236ea	--	100	Not is use today
HFC-245fa	--	790	Foam blowing agent and refrigerant
HFC-245ca	6.6	560	Not in use today, possible refrigerant in the future
CF4	50,000	6,500	Plasma etching and cleaning in semiconductor production and low temperature refrigerant
C2F6	10,000	9,200	Plasma etching and cleaning in semiconductor production
C3F8	2,600	7,000	Plasma etching and cleaning in semiconductor production, low temperature refrigerant, and fire suppressant
C4F10	2,600	7,000	Fire suppressant
c-C4F8	3,200	8,700	Not used much, if any
C5F12	4,100	7,500	Not used much, if any
C6F14	3,200	7,400	Precision cleaning solvent-low use.
NF3	740	8,000	Plasma etching and cleaning in semiconductor production
SF6	3,200	23,900	Cover gas in magnesium production and

			casting, dielectric gas and insulator in electric power equipment, fire suppression discharge agent in military systems, and formerly an aerosol propellant
C4F9O-CH3	4.1	500	Cleaning solvent and heat transfer fluid
C4F9O-C2H5	0.9	100	Cleaning solvent

ODP and GWP of Ozone Depleting Substances :

O.D.S.	Chemical Name	ODP	GWP	CAS Number
CFC-11	Trichlorofluoromethane	1.0	4000	75-69-4
CFC-12	Dichlorodifluoromethane	1.0	8500	75-71-8
CFC-113	1,1,1-Trichlorotrifluoroethane	0.8	5000	354-58-5
	1,1,2-Trichlorotrifluoroethane	0.8		76-13-1
CFC-114	Dichlorotetrafluoroethane	1.0	9300	76-14-2
CFC-115	Monochloropentafluoroethane			
Halon 1211	Bromochlorodifluoromethane	3.0		353-59-3
Halon 1301	Bromotrifluoromethane	10.0	5600	75-63-8
Halon 2402	Dibromotetrafluoroethane	6.0		124-73-2
CFC-13	Chlorotrifluoromethane	1.0	11700	75-72-9
CFC-111	Pentachlorofluoroethane	1.0		354-56-3
CFC-112	Tetrachlorodifluoroethane	1.0		76-12-0
CFC-211	Heptachlorofluoropropane	1.0		422-78-6
CFC-212	Hexachlorodifluoropropane	1.0		3182-26-1
CFC-213	Pentachlorotrifluoropropane	1.0		2354-06-5
CFC-214	Tetrachlorotetrafluoropropane	1.0		29255-31-0
CFC-215	Trichloropentafluoropropane	1.0		1599-41-3
CFC-216	Dichlorohexafluoropropane	1.0		661-97-2
CFC-217	Chloroheptafluoropropane	1.0		422-86-6
CCl_4	Carbon tetrachloride	1.1	1400	56-23-5
Methyl Chloroform	1,1,1-trichloroethane	0.1	110	71-55-6
CH_3Br	Methyl bromide	0.7		74-83-9

CHFBr2		1.0		
CHF2Br		0.74		
CH2FBr		0.73		
C2HFBr4		0.3 - 0.8		
C2HF2Br3		0.5 - 1.8		
C2HF3Br2		0.4 - 1.6		
C2HF4Br		0.7 - 1.2		
C2H2FBr3		0.1 - 1.1		
C2H2F2Br2		0.2 - 1.5		
C2H2F3Br		0.7 - 1.6		
C2H3FBr2		0.1 - 1.7		
C2H3F2Br		0.2 - 1.1		
C2H4 Br		0.07- 0.1		
C3HFBr6		0.3 - 1.5		
C3HF2Br5		0.2 - 1.9		
C3HF3Br4		0.3 - 1.8		
C3HF4Br3		0.5 - 2.2		
C3HF5Br2		0.9 - 2.0		
C3HF6Br		0.7 - 3.3		
C3H2FBr5		0.1 - 1.9		
C3H2F2Br4		0.2 - 2.1		
C3H2F2Br3		0.2 - 5.6		
C3H2F4Br2		0.3 - 7.5		
C3H2F5Br		0.9 - 1.4		
C3H3FBr4		0.08-1.9		
C3H3F2Br3		0.1 - 3.1		
C3H3F3Br2		0.1 - 2.5		
C3H3F4Br		0.3 - 4.4		
C3H4FBr3		0.03- 0.3		
C3H4F2Br2		0.1 - 1.0		
C3H4F3Br		0.07- 0.8		
C3H5FBr2		0.04- 0.4		
C3H5F2Br		0.07-0.8		
C3H6FBr		0.02-0.7		
HCFC-22	Chlorodifluoromethane	0.05	1700	75-45-6
HCFC-123	2,2-dichloro-1,1,1-trifluoroethane	0.02	93	306-83-2
HCFC-124	2-chloro-1,1,1,2-tetra fluoroethane	0.02	480	2837-89-0
HCFC-141b	1,1-dichloro-1-fluoro ethane	0.1	630	1717-00-6
HCFC-142b	1-chloro-1,1-difluoro ethane	0.06	2000	75-68-3

4.0 Substitutes of Ozone Depleting Substances

Ozone depleting substances (O.D.S.) are to be phased out, as agreed under Montreal Protocol, and hence it is prime requirement to develop new alternatives which have less or no adverse effects on the ozone layer. While developing new alternatives the cost factor needs to be considered and since consumption/production of alternatives of O.D.S. are in the interest of global environment hence the developed countries must think to transfer related technologies to the developing and under developed countries at subsidized and affordable cost in order to achieve the basic aims expeditiously.

An ideal substitute of O.D.S. must be non-toxic, non-flammable, chemically stable, compatible with refrigeration system materials, inexpensive, good transport and thermodynamic qualities with low **ozone depletion potential (ODP)** and low **global warming potential (GWP)** value. Hydrochlorofluorocarbons (HCFCs) and Hydrofluoro carbons (HFCs) are such compounds which have low or zero ODP with GWP less than the CFCS. ODP values of principal ozone depleting substances alongwith GWP values of ODS and non ODS is shown at page no.13 -16.

Various types of **substitutes of ozone depleting substances** used in Industrial air conditioning, Process refrigeration, Motor vehicle air conditioning, Water coolers, Food refrigeration, Commercial Ice Machines, Vending machines, Residential Dehumidifiers, Low temperature refrigeration, Rigid polyurethane, aerosols, sterilants, Adhesives/Coatings. Inks are given on the following pages.

4.1 Substitutes of ODS in Industrial Process Refrigeration

ODS being replaced	Substitutes	Trade Name	Retrofit/New
12,502	HCFC-22		R,N
11	HCFC-123		R,N
13,13B1,503	HFC-23		R,N
12	HFC-134a		R,N
12	HFC-227ea		N
114	HFC-236fa		R,N
12	R-401A, R-401B	MP-39, MP-66	R,N
502	R-402A, R-402B	HP-80,HP-81	R,N
13,13B1,503	R-403B	Isceon 69-L	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
502	R-407A, R-407B	Klea 407A,	R,N
502	408A		R
12,500,502	R-411A, R-411B		R,N
502	R-507	AZ-50	R,N
13,13B1,503	R-508A	Klea 5R3	R,N
12	Free Zone	FreeZone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N,
12,500	FRIGC FR-12	FRIGC FR-12	R,N
12,500	GHG-X4	GHG-X4, Autofrost Chill-it	R,N
12,500	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N
12,500,502	G2018C	G2018C	R,N
12,500	Hot Shot	Hot Shot, Kar Kool	R,N
12	HCFC-22/HCFC-142b		R,N
13,13B1,503	NARM-502		R,N
13,13B1,503	Carbon Dioxide		R,N
502	THR-04	THR-04	R,N
12,502	Ammonia Vapor Compression		N
12	Hydrocarbons (propane, butane, isobutane, propylene)	HC-12a OZ-12 Duracool 12a	N
All	Chlorine		R,N,
All	Evaporative/Desiccant Cooling		N
HCFC-22	R-410A, R-410B	AZ-20,Suva 9100, Puron	N

HCFC-22	R-507	AZ-50	N R, N
HCFC-22	Ammonia Vapor Compression		N
HCFC-22	Ammonia Absorption		N

4.2 O.D.S. Substitutes in Industrial Process Air conditioning

O.D.S. being replaced	**Substitutes**	**Trade Name**	**Retrofit / New**
114	HCFC-124		R,N
114	HCFC-22		N (below 115 degrees F ambient)
114	HFC-134a		N (below 125 degrees F ambient)
114	R-401A, R-401B,R-401C	MP-39,MP-66, MP-52	R,N,
HCFC-22	R-410A,R-410B	AZ-20, Suva 9100, puron	N
HCFC-22	R-407C	Suva 9000, Klea 66	R,N
HCFC-22	R-507	AZ-50	N
HCFC-22	Ammonia Vapor Compression		N
HCFC-22	Ammonia Absorption		N
All	Evaporative/Desiccant Cooling		N

4.3 O.D.S. Substitutes in Motor Vehicle Air Conditioners

O.D.S. being replaced	Substitutes	Trade Name	Retrofit/New
12	HFC-134a		R,N
12	HCFC-22		R,N(Buses only)
12	R-406A	GHG	R,N
12	GHG-X4, R-414A	GHG-X4, Autofrost, Chill-it	R,N
12	Hot Shot, R-414B	Hot Shot, Kar Kool	R,N
12	FRIGC FR-12, R-416A	FRIGC FR-12	R,N
12	Free Zone	Free Zone / RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N
12	Ikon 12	Ikon 12	R,N
12	Evaporative Cooling		N

4.4 O.D.S. Substitutes in Cold Storage ware houses

O.D.S. being replaced	Substitutes	Trade Name	Retrofit/New
12,502	HCFC-22		R,N
12	HFC-134a		R,N
12	HFC-227ea		N
12	R-401A, R-401B	MP-39, MP-66	R,N
502	R-402A, R-402B	HP-80, HP-81	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
502	R-407A, R-407B	Klea 407A, 407B	R,N
502	R-408A		R
12,500,502	R-411A, R-411B		R,N
502	R-507	AZ-50	R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR-12	R,N
12,500	GHG-X4	GHG-X4, Autofrost, Chill-it	R,N
12	GHG-HP	GHG-HP	R,N
12,500,502	G2018C	G2018C	R,N
12,500	Hot Shot	Hot Shot, Kar Kool	R,N
12	HCFC-22/HCFC-142b		R,N
502	THR-04	THR-04	R,N
All	Ammonia Vapor		N

	compression		
All	Evaporative/Desiccant Cooling		N
All	Pressure Step-down		N
12,500,502	Self-chilling cans using CO2		N
HCFC-22	R-410A, R-410B	AZ-20, Suva 9100, Puron	N
HCFC-22	R-407C	Suva 9000, Klea 66	R,N
HCFC-22	R-507	AZ-50	N
HCFC-22	Ammonia Vapor Compression		N

4.5 Substitutes for O.D.S. in flexible* / Rigid** poly urethanes

Refrigerant used	Substitutes
CFC-11*	Methylene chloride HFC-1340 HFC-152a Carbon dioxide Acetone AB/Electroset technology Saturated H.C. (C_3-C_6)
CFC-11**	HCFC-141b HCFC-123 HCFC-142B HCFC-22 HCFC-22/HCFC-141b blends HCFC-141b/HCFC-123 blends HCFC-22/HCFC-142b blends Formic Acid Saturated H.C. (C_3-C_6) HFC-134a HFC-152a 2-chloropropane Electroset technology Carbon dioxide
HCFCs**	Water, carbon dioxide HFC-134a HFC-152a HFC-245fa Formic Acid Saturated H.C. (C_3-C_6) ExxSol Blowing Agent

4.6 O.D.S Substitutes for flooding / streaming Agents*

ODS being replaced	Substitutes
Halon-1301	Powdered Aerosol A Powdered Aerosol B Carbon Dioxide Foam A Water mist system HFC-23 (FE 13) HFC – 125 HFC – 1340 HFC – 227ea (FM 200) HFC – 236 fa (FE-36) HCFC – 22 HCFC – 124 C_3 f_8 (PFC-218, CEA-308) C_4 F_{10} (PFC-410, CEA-410) CF_3I IG-100 (NN 100) IG – 01 IG – 55 IG – 541 (Inergen) Inert Gas, Powdered aerosol blend
Halon 1211	HCFC – 123 (FE – 232) HCFC - 124 (FE – 241) HCFC Blend (B, C,D,) Water Mist system Carbon dioxide Dry chemical HBFC – 22B1 HFC – 227 ea (FM – 200) HFC – 236 fa (FE – 36) C_6F_{14} – (PFC-614, CEA-614)

* Subject to Use Condition

4.7 O.D.S. Substitutes in Water Coolers

O.D.S. being Replaced	Substitutes	Trade Name	Retrofit/New
12	HCFC-22		N
12	HFC-134a		R,N
12	R-401A, R-401B	MP-39, MP-66	R,N
12,500	R-406 A	GHG	R
12	R-409A		R
12,500,502	R-411A, R-411B		R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR – 12	R,N
12,500	GHG-X4	GHG-X4, Autofrost, Chill-it	R,N
12,500	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N
12,500	Hot Shot	Hot Shot, Kar Kool	R,N
502	THR-04	THR-04	R,N
12	HCFC-22 / HCFC-142b		R,N

4.8 Substitutes for O.D.S. in centrifugal chillers

O.D.S. being Replaced	Substitutes	Trade Name	Retrofit/New
CFC-11	HCFC-123	--	R,N
	HCFC-22	--	N
	HCFC-134a	--	N
	HFC-227ea	--	N
	Ammonia Vapor Compression	--	N
	Evaporative Cooling	--	N
	Desiccant Cooling	--	N
	Ammonia/Water Absorption	--	N
	Water/Lithium Bromide Absorption	--	N
CFC-114	HCFC-22	--	N
	HCFC-123	--	N
	HCFC-124	--	R,N
	HFC-134a	--	N
	HFC-227ea	--	N
	HCFC-236fa	--	R,N
	Ammonia Vapor Compression	--	N
	Evaporative Cooling	--	N
	Desiccant Cooling	--	N
	Ammonia/Water Absorption	--	N
	Water/Lithium Bromide Absorption	--	N
CFC-12, 500	HCFC-22		N
	HCFC-123		N
	HFC-134a		R,N
	HFC-227ea		N
	R-406-A	GHG	R,N
	Free Zone	Free Zone/RB-276	R,N
	Freeze 12	Freeze 12	R,N
	FRIGC FR-12	FRIGC FR-12	R,N
	GHG-X4	GHG-X4, Autofrost, Chill-it	R,N
	GHG-X5	GHG-X5	R,N

	G2018C	G2018C	R,N
CFC-12	HCFC-22/HCFC-142b		R,N
CFC-12, 500	Ammonia Vapor Compression With Secondary Loop		N
	Evaporative/Desiccant Cooling		N
	Ammonia/Water Absorption		N
	Water/Lithium Bromide Absorption		N
HCFC-22	R-410A, R-410B	AZ20, Suva 9100 Puron	N
	R-407 C	Suva 9000, Klea 66	R,N
	R-507	AZ-50	N
	Ammonia Absorption or Water/Lithium Bromide Absorption		N
	Evaporative/Desiccant Cooling		N

4.9 O.D.S. Substitutes for Aerosol propellants

Substitutes for CFC-11	**Substitutes for HCFC-22 and HCFC-142b**
Saturated light hydrocarbons, C3-C6 (e.g., propane, isobutane, n-butane)	Saturated light hydrocarbons, C3-C6 (e.g. propane, isobutane, n-buane)
Demethyl ether	Dimethyl ether
HFC-152a, HFC-125, HFC-134a	HFC-152a, HFC-125, HFC-134a
HFC-227ea	HFC-227ea
Alternative processes (pumps, mechanical pressure dispensers, non-spray dispensers)	Alternative processes (pumps, mechanical pressure dispensers, non-spray dispensers)
Compressed Gases (carbon dioxide, air, nitrogen, nitrous oxide)	Compressed Gases (carbon dioxide, air, nitrogen, nitrous oxide)

4.10 Substitutes for O.D.S. in Commercial Ice Machines

O.D.S. being Replaced	Substitutes	Trade name	Retrofit / New
12,502	HCFC-22	--	N
12	HFC-134a	--	N
12	R-401A, R-401B	MP-39,MP-66	R,N
502	R-402A, R-402B	HP-80,HP-81	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
502	R-407A,R-407B	Klea 407A, 407B	R,N
502	R-408A	--	R
12	R-409A	--	R
12,500,502	R-411,R-411B	--	R,N
502	R-507	AZ-50	R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12	FRIGC FR-121	FRIGC FR-12	R,N
12,500	GHG-X4 Autofrost, Chill-it	GHG-X4,	R,N
12,500	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N

12,500,502	G2018C	G2018C	R,N
12,500	Hot Shot	Hot Shot, Kar Kool	R,N
12	HCFC-22 HCFC-142b	--	R,N
502	THR-04	THR-04	R/N
all	Ammonia Vapor Compression	--	N
22	R-410, R-410B	AZ-20, Suva 9100, Puron	N
22	R-507C	AZ-50	N
22	R-407C	Suva 9000, Klea 66	R,N
22	Ammonia Vapor Compression	--	N
22	Ammonia Absorption	--	N

4.11 Substitutes for O.D.S. in Food Refrigeration

O.D.S. being Replaced	Substitutes	Trade Name	Retrofit / New
12,502	HCFC-22	--	R,N
12	HFC-134a	--	R,N
12	HFC-227ea	--	N
12	R-401A,R-401B	MP-39,MP-66	R,N
502	R-402A, R-402B	HP-80,HP-81	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
502	R-407A, R-407B	Klea 407A, 407B	R,N
502	R-408A	--	R
12	R-409A	--	R
12,500,502	R-411A, R-411B	--	R,N
502	R-507	AZ-50	R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR-12	R.N
12,500	GHG-X4	GHG-X4	R,N
12,500	GHG-X5	GHG-X5	R,N

12	GHG-HP	GHG-HP	R,N
12,500,502	G2018C	G2018C	R,N
12,500	Hot Shot	Hot Shot Kar Kool	R,N
12	HCFC-22/HCFC- -142b	--	R,N
502	THR-04	THR-04	R,N
all	Ammonia Vapor Compression With Secondary Loop	--	N
12,500,502	Self chilling cans using CO_2	--	N
22	R-410A, R-410B	AZ-20, Suva 9100, Puron	N
22	R-407C	Suva 9000, Klea 66	R,N
22	R-507	AZ-50	N
22	Ammonia Vapor Compression With Secondary Loop	--	N

4.12 Substitutes for O.D.S. in Refrigerated Transport

O.D.S. being replaced	Substitutes	Trade Name	Retrofit / New
12,502	HCFC-22	--	R,N
12	HFC-134a	--	R,N
12	R-401A, R-401B	MP-39,MP-66	R,N
502	R-402A, R-402B	HP-80,HP-81	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
502	R-407A, R-407B	Klea 407A,407B	R,N
502	R-408A	--	R
12	R-409A	--	R
12,500,502	R-411A, R-411B	--	R,N
502	R-507	AZ-50	R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR-12	R,N
12,500	GHG-X4,	GHG-X4 Autofrost, Chill-it	R,N
12,500	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N
12,500,502	G2018C	G2018C	R,N

12,500	Hot Shot,	Hot Shot, Kar Kool	R,N
12	HCFC-22/HCFC-142b	--	R,N
502	THR-04	THR-04	R,N
all	Direct Nitrogen Expansion	--	N
all	Stirling Cycle	--	N
12,500,502	Self-chilling cans using CO2	--	N
22	R-410A, R-410B 9100, Puron	AZ-20, Suva 9100 Puron	N
22	R-407C	Suva 9000, Klea 66	R,N
22	R-507	AZ-50	N

4.13 Substitutes for O.D.S. in Low Temperature Refrigeration

O.D.S. being Replaced	Substitutes	Trade mark	Retrofit / New
12,13,13B1,503	HFC-23	--	R,N
13,13B1,503	R-403B	Isceon 69-L	R,N
13,13B1,503	R-508A	Klea 5R3	R,N
12,13B1,503	R-508B	Suva 95	R,N
13,13B1,503	Carbon Dioxide	--	R,N
13,13B1,503	NARM-502	--	R,N

4.14 Substitutes for O.D.S. in Vending Machines

O.D.S being Replaced	Substitutes	Trade name	Retrofit / New
12,502	HCFC-22	--	R,N
12	HFC-134a	--	R,N
12	R-401A, R-401B	MP-39, MP-66	R,N
502	R-404A	HP-62	R,N
12,500	R-406A	GHG	R
12	R-409A	--	R
12,500,502	R-411A, R-411B	--	R,N
502	R-507	AZ-50	R,N
12	Free Zone	Free Zone/RB-276	R,N
12	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR-12	R,N
12,500	GHG-X4	GHG-X4 Autofrost, Chill-it	R,N
12,500	GHG-X5	GHG-X5	R,N
12	GHG-HP	GHG-HP	R,N
12,500,502	G2018C	G2018C	R,N
12,500	Hot Shot	Hot Shot, Kar Kool	R,N
502	THR-04	THR-04	R,N
12	HCFC-22/HCFC-142b	--	R,N
12,500,502	Self-chilling cans using CO2	--	N

4.15 Substitutes for O.D.S. in Residential Dehumidifiers

O.D.S. being Replaced	Substitutes	Trade Name	Retrofit / New
12,500	HCFC-22	--	R,N
12,500	HFC-134a	--	R,N
12,500	R-401A, R-401B	MP-39, MP-66	R,N
12,500	R-406A	GHG	R
12,500	R-409A	--	R
12,500	Free Zone	Free Zone/RB-276	R,N
12,500	Freeze 12	Freeze 12	R,N
12,500	FRIGC FR-12	FRIGC FR-12	R,N
12,500	GHG-X4	GHG-X4	R,N
12,500	GHG-X5	GHG-X5	R,N
12,500	GHG-HP	GHG-HP	R,N
12,500	Hot Shot	Hot Shot Kar Kool	R,N
12	HCFC-22/HCFC-1420	--	R,N

4.16 Substitutes for O.D.S. in Sterilants

O.D.S. being replaced	Substitutes	Comments
12/88 blend of ethylene oxide and CFC-12	CO_2/EtO	CO_2/EtO blends can serve as drop-in replacements to 12/88 in some but not in all existing equipment because they require a higher operating pressure.
	HCFC-124/EtO	HCFC-124 is an ozone depleting substance; it should be used to sterilize only equipment that can not be sterilized using other alternatives such as steam or CO_2/EtO blends.
	[HCF Blend]	This blend contains HCFC-124, an ozone depleting substance, it should be used to sterilize only equipment that can not be sterillized using other alternatives such as steam or CO_2/EtO blends.
	Pure EtO	EtO is toxic, carcinogenic substance and is considered a hazardous air pollutant. Potential exposures of the general population to EtO releases can be limited either through the use of catalytic converters which convert waste EtO in to CO2 and water, or through the use of acid water scrubbers which convert waste EtO into ethylene glycol. Must be used in accordance with manufacturer recommendations to address flammability concerns. Must be used in accordance with OSHA standards to limit occupational exposures.
	Acid/Hydrogen per oxide gas Plasma System	--
	Hydrogen Peroxide Gas Plasma Systems	--
Steam	---	Applicable only to devices resistant to heat and moisture.

4.17 Substitutes for O.D.S. in Adhesives, Coatings and Inks

O.D.S. Used	Substitutes	Comments
Methyl chloroform	Petroleum Hydrocarbons	OSHA standards exist for many of these chemicals. Formulators should use chemical with lowest toxicity, where possible.
	Oxygenated solvents (Alcohols, OSHA ketones, Ethers, and estrers)	OSHA standards exist for many of these chemical formulators should use chemicals with lowest toxicity, where possible.
	Chlorinated solvents (methylene chloride, Trichloro-ethylene, Perchloroethylene)	High inherent toxicity. Use only when necessaryChloride, OSHA and RCRA standards must be met.
	Terpenes	--
	Water-based formulations	--
	High-solid formulations	--
	Alternative technologies (e.g., powder, Hot melt, thermoplastic plasma spray, Radiation-cured, moisture-cured, Chemical-cured, and reactive liquid)	
Methyl Chloroform	Monochlorotoluene/ Benzotrifluorides	The Workplace standard for monochloro-toluenes is based On an OSHA of 50 ppm for Orthochlorotolune. The work-place Standard for Benzotrifluoride is Based, on a recent toxicology sutdy.
	Trans-1,2-dichloro-Ethylene	The OSHA set exposure limit (PEL) is 200 ppm

5.0 MANUFACTURERS & SUPPLIERS OF ALTERNATIVE O.D.S.MATERIALS AND/OR EQUIPMENTS

Code No.	Name of Supplier
024.1	3M Argentina S.1A.C.I.F.I.A. Los Arboles 842, 1686 Hurligham, Provincia de Buenos Aires, Argentina. Tel: +54 (1) 665 0661; Fax: +54 (1) 665 4071.
048.10	3M Europe S.A., 106 Boulevard De La Woluwe, B-1200 Brussels, Belgium. Tel: +32 (2) 761 2211; Fax: +32 (2) 762 7978
054.1	S.A. Mica Isolamentos S.A., Hans Frenster, A1, Rio Negro 1105, 5, Ander C.J. 52, 06400 Baruri, Sao Paulo, Brazil, Tel: +55 (11) 725 3508; Fax: +55 (11) 914 5722.
072.1	San Lab Systems 1000 Timmins Gardens, Pikering Ontario, L1W-2L2, Canada, Tel: +1 (905) 8370 347; Fax: +1 (905) 8318 971.
084.1	F.H. Engel S.A., Casilla 61D, Santigo, Chile Tel: +56 (2) 236 1227; Fax: +56 (2) 235 7834.
147.1	Du Pont de Nemours (France) S.A., 137, Rue de L'Universite, F 75334, Paris, Cedex 07, France. Tel: +33 (1) 4550 6443; Fax: +33 (1) 4551 4454.

231.2 Shinnika PPG Co. Ltd.,
CNR International,
R&D/Manufacturing Facility,
12-1 Shinminato Kisarazu-Shi,
Chiba-Ken 292, Japan

231.3 Sumitomo 3M Limited
33-1, Tamagawadai 2-chrome,
Setagaya-Ku, Tokyo, P.O. Box 43,
Tamagawa Tokyo, 158,
Japan.
Tel: +81 (3) 3709 8111;
Fax: +81 (3) 3709 8111.

391.1 3M Asia Pacific PTE Ltd.,
9 Tagore Lane,
Singapore 2678,
Tel: +65 454 8611;
Fax: +65 458 5432.

391.2 Du Pont Singapore Pte. Ltd.,
1 Maritime Square,
#07-01 World Trade Centre,
Singapore 0409,
Tel: +65 273 2244;
Fax: +65 272 7494.

391.3 Specialty Chemicals,
Rositah Adul Ghani,
45 Kallang Pudding Road,
06-01 & 06-03 Alpha Building,
Singapore 1334
Tel: +65 743 8633;
Fax: +65 747 3729.

453.1 Lipsner Smith Company,
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Business Center,
Waterloo Road,
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Fax: +44 (895) 274 692.

453.3 Specialty Chemicals
Christopher Chapman,
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Tel: +44 (62) 266 1991;
Fax: +44 (62) 275 8343.

456.1 Bic Corporation,
Export Division,
500 Bic Drive,
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The United States

Tel: +1 (203) 7832 000;
Fax: +1 (203) 7832 131.

456.3 Chemtronics Inc.
8125, Cobb Center Drive,
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The United States,

Tel: +1 (404) 424 4888;
Fax: +1 (404) 424 4267.

456.4 Ciba-Geigy Corp.,
Doug Parkes, P.O. Box 18300,
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The United States,

Tel: +1 (910) 632 2488;
Fax: +1 (910) 632 7098.

456.5 3M Consumer Specialities Division,
3M Center, St. Paul, MN 55144-1000,
The United States.

Tel: +1 (612) 733 1553;
Fax: +1 (612) 733 4012.

456.7 Du Pont de Nemours,
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Wilmington, DE 19880-0029,
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Fax: +1 (302) 992 3903.

456.8 Eberhard-Feber, Inc.
Corporate Headquarters,
4 Century Drive,
Parsippany,
NJ 07054,
The United States.

Tel: +1 (201) 5394 111;
Fax: +1 (201) 5394 537.

456.9 Eberhard-Faber, Inc.,
Customer Services,
P.O. Box 2630,
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Lewisberg.
TN 37091-2630
The United States,
Tel: +1 (615) 3591 583;
Fax: +1 (615) 3597 680.

456.10 Evode-Tanner,
Furman Hall Court, P.O. Box 1967,
Greenville, SC 29602
The United States.
Tel: +1 (803) 232 3893;
Fax: +1 (803) 232 3094.

456.11 Fiber Shield Industires Inc.,
85 V. South Hoffman Lane,
Islandia, NY 11722,
The United States.
Tel: +1 (516) 348 2585;
Fax: +1 (516) 348 1110.

456.13 Gillete Company,
The Paper Mate/
Stationery Products Division,
Box 61, Boston,
MA 02199,
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Tel: +1 (617) 4217 000;
Fax: +1 (617) 4218 014.

456.15 HBG Export Corporation,
456 South Anderson Road, BTC 506,
Rock Hill, SC 29730,
The United States.
Tel: +1 (803) 366 9411;
Fax: +1 (803) 366 2129.

456.16 International Division
Attn. Will Nadal,
P.O. Box 31,
Bounbrook, NJ 08805,
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Tel: +1 (908) 469 7377
Fax: +1 (908) 469 8952

456.17 IVAX Industries Inc.,
1880 Langson Street,
Rock Hill SC 29730,
The United States.
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Fax: +1 (404) 493 9206.

456.18 Lipsner Smith Company,
4700 Chase Avenue,
Lincolnwood,
IL 60646-1689,
The United States;
Tel: +1 (708) 6773 000;
Fax: +1 (708) 6771 311.

456.19 LPS Laboratories Inc.,
4647 Hugh Howell Road,
Tucker, GA 30085-5052,
The United States,
Tel: +1 (404) 934 7800;
Fax: +1 (404) 493 9206.

456.21 Micro Care Corp.,
34 Ronzo Road, Bristol, CT 06010,
The United States,
Tel: +1 (203) 585 7912;
Fax: +1 (203) 585 7378.

456.22 Miller-Stephenson
Chemical Company Inc.,
George Washington Highway,
Danbury, CT 06810,
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Tel: +1 (203) 743 4447;
Fax: +1 (203) 791 8702.

456.23 NICCA,
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Fountain Inn, SC 29644,
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Tel: +1 (803) 862 1426;
Fax: +1 (803) 862 1427.

456.25 PPG Industries,
P.O. Box 040004,
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AL 35804,
The United States.
Tel: +1 (205) 8517 001;
Fax: +1 (205) 8518 822.

456.27 3M Protective Chemicals Division,
3M Center, St. Paul MN 55144-1000,
The United States,
Tel: +1 (612) 733 1110;
Fax: +1 (612) 733 9973.

456.28 Radio Frequency Company,
150 Dover Road,
Millis, MA 02054
The United States.
Tel: +1 (617) 7624 900;
Fax: +1 (617) 7624 952.

456.30 Repeat-o-Type Manufacturing Corp.,
International Department,
665 State Highway - 23,
Wayne NJ 07470,
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Tel: +1 (201) 6963 330
Fax: +1 (201) 6947 287

456.31 Sentry Chemical Co. Inc.,
Dept. 3, P.O. Box 748,
1481 Rock Mountain Boulevard,
Stone Mountain, GA 30086,
The United States,
Tel: +1 (404) 934 4242;
Fax: +1 (404) 934 0932.

456.32 Sequa Chemicals incorporated,
1 Sequa Drive, Chestr., SC 29706,
The United States.
Tel: +1 (803) 385 5181;
Fax: +1 (803) 377 3542.

456.35. Technical Film Systems
9205 Alabama Avenue,
Unit D, Chatsworth,
CA 91311
The United States,
Tel: +1 (818) 7090 515;
Fax: +1 (818) 7090 317.

456.37. Wite-Out Products,
145 South Chase Blvd.,
Fountain Inn.
Sc 29644,
The United States,
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Fax: +1 (803) 9670 449.

456.38 Yorkshire PAChem,
P.O. Box 1926, Greenvile, SC 29602,
The United States,
Tel: +1 (803) 233 3941;
Fax: +1 (803) 232 3542.

456.39 Zip-Chem Products,
1860 Dobbin Drive,
San Jose, CA 95133,
The United States,
Tel: +1 (408) 729 0291;
Fax: +1 (408) 272 8062.

525.1 Eberhard Faber, Inc.,
AW Faber Germany,
8504 Stein Bei,
Nuremburg,
Germany,
Tel: +49 (911) 66791
Fax: +49 (911) 66798.

525.2 Phersee Chemie,
Hans Peter Rafael,
Rehlinger Strasse 1,
D 8901, Langweid,
Germany,
Tel: +49 (823) 041 285;
Fax: +49 (823) 041 384.

575.1 Du Pont de Nemours Intl. S.A.,
Fluorochemicals Division,
P.O. Box 50, 2 Chemin Du Pavillon,
CH-1218 Le Grane-Saconnex, Geneva,
Switzerland,
Tel: +41 (22) 717 5111;
Fax: +41 (22) 717 5664.

626.1 3M Zimbabwe (Pvt.) Ltd.,
P.O. Box AY 64, Amby, Harare,
Zimbabwe,
Tel: +263 (4) 46164;
Fax: +263 (4) 46165.

* Film Cleaning Machine
(Perchloroethylene immersion system)
use 1,1,1-trichloroethane

-- Supplier of Alternative machines and
this ODS are 456.18 and 453.1

* Non-immersion cleaning system for film cleaning
also use 1,1,1-trichloroethane.

-- Supplier of alternative equipment and ODS
are 456.18, 453.1 and 072.1

* Distilled water based spray cleaning system of
film also use ODS 1,1,1 trichloroethane

-- Supplier of alternative equipment and ODS
are 456.35, 456.28, 456.18, 453.1 and 072.1

* Correction fluid has use of 1,1,1-trichloroethane

-- Supplier of alternative material of ODS and
equipment are 525.1, 456.37, 456.30, 456.13,
456.19, 456.8 and 456.1.

* Aerosol dusters (HFC - 134a and HFC - 152 a sprays)
are used for general maintanance and repair facilities
for precision instrument
ODS to be replaced - CFC - 12, HCFC - 22.

-- Supplier are 456.3, 456.21, 456.22 and 456.39.

* Aerosol Cleaners/Flux removers are used for general
cleaning of parts and printed circuit boards which use
1,1,1,-trichloroethane, CFC - 113, HCFC - 141b.

-- Supplier of alternatives of above ODS and equipment are
456.3, 456.19 and 456.39

* Aerosol fabric protectants are used for home fabric
maintenance which make use of 1,1,1-trichloroethane

-- Supplier of alternatives are 456.11, 054.1,
456.31, 391.3, 453.3, 456.5, 456.27, 048.1,
024.1, 391.1, 626.1, and 231.3, 048.1, 024.1,

391.1, 626.1 and 231.3.

* Mill applied fabric protectants are used by textile mills which use ODS.

-- Suppliers of alernatives of these ODS are 456.5, 456.7, 147.1, 575.1, 391.2, 456.10, 084.1, 456.15, 456.17, 456.16,456.23, 525.2, 456.32, 456.5, 456.27, 048.1, 024.1, 391.1, 626.1, 231.3 and 456.38.

Manufacturers of Halon Substitutes

*** 3M**
Paul Rivers
3M Center Building, 236-1B-07,
St. Paul, MN55144-1000
(651) 733-0029
(651) 733-4335 (FAX)
perivers2@mmm.com
C6F14(CEA-614);
C4F10 (CEA410);
C3F8 (CEA-308)

*** ADI Technologies, Inc,**
Jerry Brown
1487 Chain Bridge Road, Suite 204,
McLean, VA22101,
(703) 734-9626,
(703) 448-8591 (FAX)
adit22101@aol.com
Powedred Aerosol A (SFE)

*** AES International Pvt. Ltd.,**
Julia Berezovsky
9 Gloucester Road, Hurstville,
P.O. Box 694, Hurstville,
NSW 2220 Australia
61-2-9586-3200
61-2-9586-3211 (FAX)
pyrogen@fl.net.au
www.pyrogen.com
Powdered Aerosol C (PyroGen)

*** Americn Pacific Corporation**
Halotron Division,
Jeff Gibson
3770 Howard Hughes Parkway Suite 300
Las Vegas NV 89109,
(702) 699-4184,
(702)735-4876 (FAX)
halotron@apfc.com
www.halotron-inc.com
HCFC Blend B (Halotron)

*** Ansul Fire Protection**
David Pelton
1240 Iroquois Drive, Suite 102,
Naperville, IL 60563-8537,
(630) 305-5700
(630) 305-3360 (FAX)
dpelton@tyco.geis.com
www.ansul.com
IG-541 (Inergen)

*** Dupont Fluoroproducts**
Daniel Moore
Chestnut Run Plaza
P.O. Box 80702,
Wilmington,DE 19880-0702
(302) 999-4459,
(302) 999-2816 (FAX)
daniel.w.moore@usa.dupont.com
www.dupont.com/fire
HFC-23(FE-13);
HFC-125(FE-25);
HFC-236fa (FE-36);
FCFC-123 (FE-232);
FCFC-124 (FE-241)

*** Firefox Industries**
James Zwergel
3896 Sardis Road,
Murrayville, PA 15668,
1-800-930-3366
(724)733-3822
(724)733-3823 (FAX)
info@firefoxind.com
www.firefoxind.com
Foam A

*** Firefreeze Worldwide, Inc.**
Stephanie E.Giessler,
270 Route 46 East,
Rockaway, NJ 07866,
(973)627-0722
(973)627-2982 (FAX)
info@firefreeze.com
www.firefreeze.com
[Surfactant Blend] A (cold fire)

*** Ginge-Kerr Danmark A/S**
Jacob O. Pederson
111, Stamholmen
DK2650 Hvidovre,
Denmark
45-3677-1131
45-3677-2231 (FAX)
ginge@ginge-kerr.dk
www.kidde-int.com
IG-55(Argonite)

*** Great Lakes Chemical Corporation**
Steven Ginn
P.O. Box 2200,
West Lafayette, IN 47906,
(765) 497-6390
(765) 463-2849 (FAX)
sginn@glcc.com
www.fm-200.com
HFC-227ea (FM-200)

*** International Management Services Corp.**
Joseph Brown
8298 D Old Courthouse Road,
Vienna, VA 22182,
(703) 448-4487,
(703) 847-6430(FAX)
imscorp@ix.netcom.com
Powdered Aerosol C (Soyuz)

*** Koatsu Company, Ltd.,**
Nobuo Yamada
310, Kitahonmachi,
1-Chome, Itami,
Hyogo 664-0836, Japan
81-0727-82-8561
81-0727-82-8414 (FAX)
info@koatsu.co.jp
www.Koatsu.co.jp
IG-100(NN100)

*** Marioff Oy Matt Gustafson**
3600 Commerce Drive
Suite 614
Baltimore, MD 21227
410-737-6600

410-737-6489 (FAX)
www.hi-fog.com
Water Mist Systems

*** Minimax GmbH**
Wolfgang Koch
Industriestrasse 10/12
23840 Bad Oldesloe, Germany
49-4531-803443,
49-4531-803500 (FAX)
w.koch@minimax.de
www.minimax.de
IG-01(Argotec)

*** Newhouse International Inc.**
Steve Newhouse
7229 East Criollo Circle
Orange, CA 92869
(714) 771-6466
(714) 771-6475 (FAX)
CF31@concentric.net
CF31(Triodide)

*** Nohmi Bosai Ltd.,**
Tadashi Tanoue
7-3, Kudan-Minami,
4-Chome, Chiyoda-ku
Tokyo 102-8277, Japan
81-03-3265-0211
81-03-3265-9228 (FAX)
kouhou@nohmi.co.jp
www.nohmi.co.jp
IG-100 (NN100)

*** North American Fire Guardian**
Elio Guglielmi, Unit 300
625 West Kent Avenue North
Vancouver, BC Canada V6P 6T7,
604-323-0090
604-323-0051 (FAX)
nafgt@ultranet.ca
www.nafgt.com
HCFC Blend A(NAF S-III);
HCFC Blend C(NAF P-III);
HCFC Blend D(Blitz);
HCFC Blend E
(NAF P-IV)

*** Powsus Inc.**
Harry Stewart
3120 North A1A
#1403, Fort Pierce, FL34949,
(561)460-8729
(561)460-8730 (FAX)
753-0094@mcimail.com
Gelled Halocarbon/Dry Chemical Suspension (PGA)

*** Primex Aerospace Company**
Jerry White
P.O. Box 97009
Redmond, WA98073-9709
(425) 885-5000
(425)882-5744(FAX)
jdw@red.primextech.com
www.primextech.com
Inert Gas/Powdered Aerosol Blend (FS 0140)

*** Securiplex Technologies**
Maher Hanna
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Dorval, Quebec Canada H9P 2W2
514-633-1000
514-633-8338 (FAX)
hanna.m@securiplex.com
www.securiplex.com
Water Mist Systems

*** Summit Environmental Corporation, Inc.**
Keith Parker
414 East Loop 281, Suite 7
Longview, TX 75605
903-758-0540
903-758-1903 (FAX)
seci@iamerica.net
www.summitenvironmental.com
[Surfactant Blend] (Flame Out)

*** Yates Fire Protection**
H.James Yates
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Hampton, Va23670
(757) 827-8696
(757)827-8697 (FAX)
Water Mist System

6.0 RECOMMENDATIONS

There has been an international understanding and most of the countries have agreed to content this problem of ozone depletion. Still there are some measures which can be looked in to or be abide by to keep a check on this problem. Some of the suggestive measures are as follows :

1. Ensuring earliest implementation of O.D.S. (Regulation and Control) Rules will help to meet the goals and achieve the set target of phasing out chemicals which affect the ozone layer.

2. Development of inventory of ODS, based on the present stocks, at national level would be helpful to ensure their timely phase out and observe requisite safety norms.

3. Public education and awareness programmes must be undertaken by Government as this could be of benefit to the users and general public/citizens.

4. Emissions resulting from leak testing with CFC-12 can be prevented by using HCFC, nitrogen or other dry gases to minimize the problem.

5. Using CFCs during installation to remove moisture from equipment is another cause of emission and this can be prevented by switching to other techniques.

6. Transportation of CFC containing instruments/equipment or leakage of vessels must be safe to avoid any leakage or burst.

7. The equipment with ODS must be protected from vibrations.

8. Refrigeration equipment must not be treated as other domestic refuse and it should be seen that CFC refrigerant is recovered from domestic system before disposal.

9. CFCs pipeline/tubes and storage facilities must be routinely inspected.

10. Long term substitutes of ODS need to be pressed in to use rather than inter mediate substitute to root out the problem.

11. Some of the basic problems like commercial availability of ODS substitutes, technology and equipment development, cost economics involved in change over to the alternates etc. must be taken up on priority to give a pace to this global activity.

7.1 Phase-out Schedule for Ozone Depleting Substances

S. No.	Name of Activities	Name of Group of Ozone Depleting Substances	Phaseout Date
1.	Manufacture of Aerosol products or pressurised dispensers (excluding metered dose inhalers for medicinal purpose).	Group I	1-1-2003
2.	Manufacture of Polyol for foam products	Group I	1-1-2003
3.	Manufacture of foam products including foam part of Domestic Refrigerator.	Group I	1-1-2003
4.	Manufacture of Fire Extinguishers or Fire Extinguishing Systems.	Group II	1-12001
5.	Manufacture of Mobile Air-Conditioners and charging at Automobile industry	Group I	1-1-2003
6.	Manufacture of other Refrigeration and Air-conditioning products (excluding compressors)	Group I	1-1-2003
7.	Manufacture of different products	Group I, III,IV & V	1-1-2010
8.	Servicing of fire extinguishers and fire extinguishing systems.	Group II	1-1-2010
9.	Manufacture for Metered Dose inhalers for medicinal purposes.	Group I	1-1-2010
10.	Manufacture of different products	Group VI	1-1-2040
11.	Use of methyl bromide except preshipment & quarantine	Group VII	1-1-2015

7.3 O.D.S. Substitutes and their Composition

ODS Substitutes	Trade Name	Composition
Acetone		C_3H_6O
Ammonia Vapour Compression		
Ammonia Vapour Absorption		
Aqueous cleaners		
Benzotrifluorides		$C_7H_5F_3$
Carbon di oxide		CO_2
2 Chloropropane		C_3H_7Cl
Acid/Hydrogen peroxide gas-plasma system		
Ethylene oxide		C_2H_4O
C5 – C20 petroleum hydrocarbons		
Exxsol Blowing Agent		
Electroset technology		
Direct Nitrogen expansion		
Freeze 12	Freeze-12	
FRIGC FR-12 (HCFC blend beta)	FRIGC-FR-12	HCFC-124,HFC-134a and butane
Free zone (HCFC blend delta)	RB-276	HCFC
Foam A		
Formic acid		
GHG-X4	Auto frost, chill it	
GHG-X5	GHG X5	
GHG-HP (HCFC blend lambda)	GHG-HP……..	HCFC-22,HCFC-142b and isobutane
G2018C	G 2018 C	
HBFC 22B1		
HCFC-22		$CHClF_2$
HFC-134a		CH_3CH_2F
HCFC-22/HCFC-142b		$CHClF_2/CClF_2CH_3$
Hot shot	Kar kool, Hot shot	
HFC-23		CHF_3
HCFC-123		$CHCl_2CF_3$
HCFC-141b		
HFC-236fa		Perfluoroisobutylene
HFC-152 a		CHF_2CH_3
HFE		Hydrofluoroether, $C_4F_9OCH_3$
HFC-4310 mee		
HCFC – 225 Ca/Cb		$CF_3CF_2CHCl_2$/ CF_2ClCF_2CHClF
HFC-245 Fa		
HCFC-14b and its blends		
HCFC-124/EtO		

HCFC-227 ea		C_3HF_7
HFC blend		
HFC-125		CF_3CHF_2
Hydrogen peroxide gas-plasma system		
IG-100		Pure Nitrogen
IG-01		100% Argon
IG-55		50% N_2, 50% Ar
IG541 (Inergen)		
Ikon-12		CF_3I
NARM-502		HCFC-22,HFC-23,HFC-152a
Methylene Chloride		
Monochlorotoluenes		
Oxygenated solvents		
PFC blend alpha.		HFC-23, R-116
Petroleum Hydrocarbons		
Perchloro ethylene		
R-401 A	MP-39	
R-402 B	MP-66	
R-402 A	HP-80	HCFC-22, HFC-125 and propane
R-402 B	HP-81	HCFC-22, HFC-125 and propane
R-404 A	HP-62	HFC-125,HFC 143a
R-406 A	GHG	HCFC-22, HCFC-142b and isobutane
R-407 A	Klea 407 A	HFC-32, HFC-134a and HFC-125
R-407B	Klea 407 B	HFC-32,HFC-134a, and HFC-125
R-408 A (HCFC blend epsilon)		HCFC-22,HFC-134a and HFC-125
R-409 A (HCFC Blend Gamma)		HCFC-22,HCFC-142b and HCFC124
R-411 A		HCFC-22,HFC-152a & Propylene
R-411 B		HCFC-22,HFC-152a & propylene
R-507		---
R-410 A	AZ – 20	HFC-32 and HFC–125
R-410 B	Suva	HFC-32 and HFC–125
R-407 C	Suva 9000, Klea 66	HFC-32, HFC-134a and HFC-125
R-414 A		
R-414 B		
R-416 A		

R-507	AZ-50	HFC-125 and HFC-143 a
R-403 B	Isceon, 69-L	HCFC-22, R-218 and Propane
R-508 A	Klea 5 R3	PFC blend alpha
R-508 B	Suva 95	
R-508		HCFC-23 & R-116
R-503		HCFC-23 & R-116
Semi aqueous cleaners		
Super critical fluids		
Terpenes		
THR – 04	THR-04	
Trans-1,2 dichloro ethylene		
Trichloro ethylene		
Vanishing oils		
Volatile methyl siloxanes		
Water based formulations		
R-218 (Octofluropropane)		C_3F_8

7.4 References and Useful Web-sites

(1) Ozone Depleting Substances (Regulation and Control) Rules, 2000. Notification of Govt. of India, Ministry of Environment & Forests, number S.O.670(E) dt. 19th July 2000.

(2) www.epa.gov/ozone/title6/snap/lists/indproc.html

(3) www.epa.gov/ozone/title6/snap/lists/114 indac.html

(4) www.epa.gov/ozone/title6/snap/lists/mvacs.html

(5) www.epa.gov/ozone/title6/snap/lists/watcool.html

(6) www.epa.gov/ozone/title6/snap/lists/othcent.html

(7) www.epa.gov/ozone/title6/snap/lists/stream.html

(8) www.epa.gov/ozone/title6/snap/lists/tobacco.html

(9) www.epa.gov/ozone/title6/snap/lists/coldstor.html

(10) www.epa.gov/ozone/title6/snap/lists/flexible.html

(11) www.epa.gov/ozone/defns.html

(12) www.unep.org/ozone

(13) www.unepie.org/ozoneaction.html

(14) www.epa.gov/ozone/mdi/mdi.html

(15) www.unep.ch/ozone

(16) www.ec.gc.ca/ozone/protect/sect8.html

(17) www.unep.org/ozone/Beijing -Amendment

(18) www.unep.org/ozone/montreal.html

(19) www.unep.org/ozone/treaties.html

(20) www.epa.gov/ozone/geninfo/gwps.html

(21) “The Montreal Protocol, India’s Success Story”, II edition, Published by Ozone Cell, MoEF, Government of India, New Delhi.