22-020816-CLN-01

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: CHI ABSORBER FIELD NULLING COIL DESCRIPTION, REVISED

This memo provides basic information concerning the CHI Absorber Field Nulling Coils

Coil Descriptions

As shown in figure 1, there are two coils, named PFAB1 and PFAB2 ("PF" stands for poloidal field, "AB" stands for absorber). Note also the flux loop "FL" locations above and below PFAB1 at r,z=(0.4401m,1.6962m) and r,z=(0.4401m,1.8169m) and also under PFAB2 at r,z=(0.6187m,1.8544m).

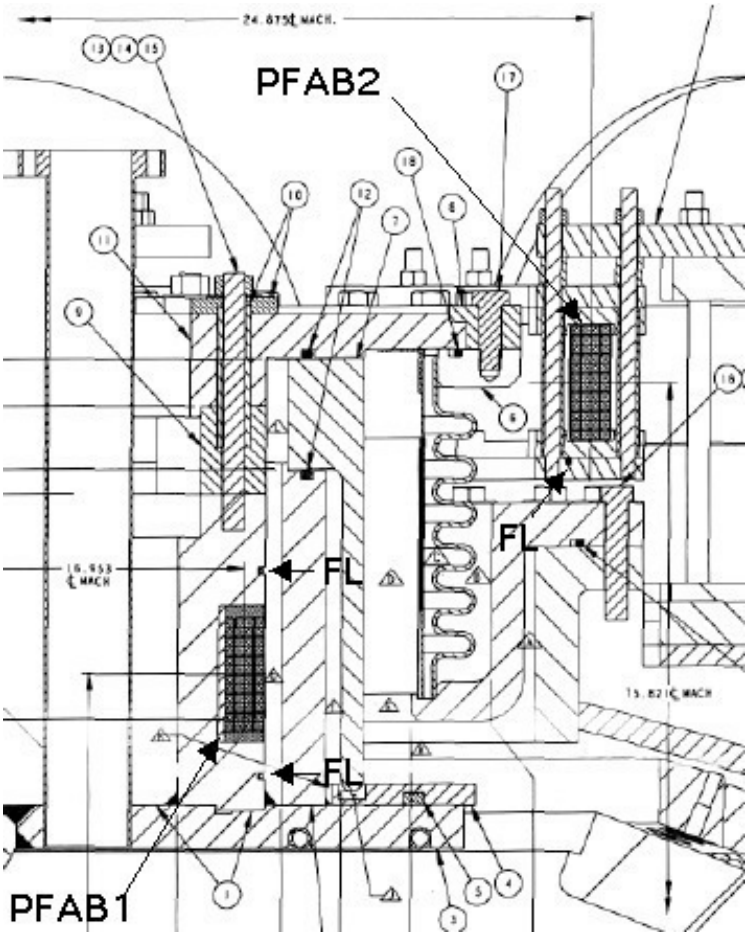

FIGURE 1: PF ABSORBER FIELD NULLING COILS (Dwg. E-DC1277)

Coil construction details are shown in figures 2 and 3.

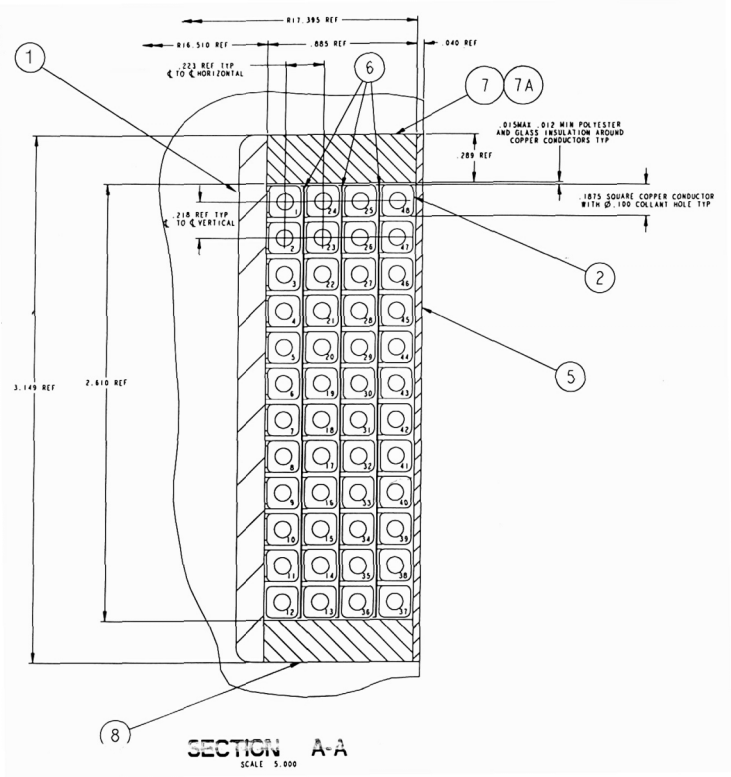

FIGURE 2: PFAB-1 (Dwg. E-DC1284)

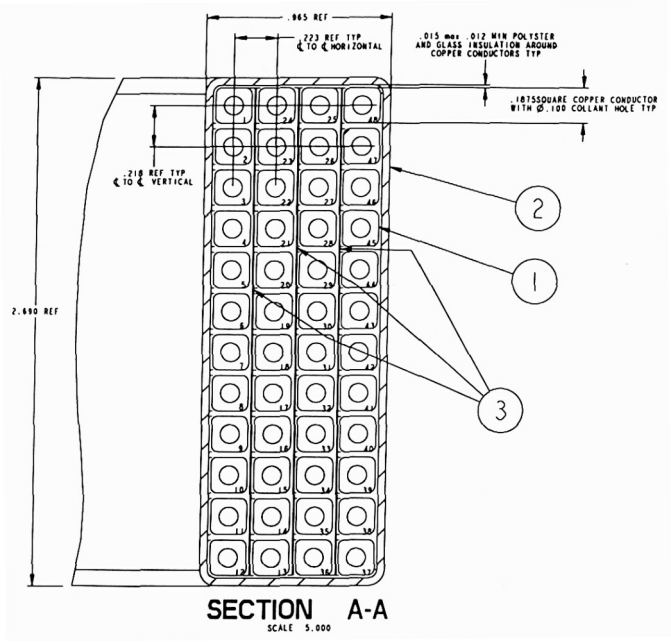

FIGURE 3: PFAB-2 (Dwg. E-DC1286)

Coil dimensions are given in Table 1, and electrical impedances in Table 2. Coil electrical ratings are given in Table 3.

Table 1: CHI Absorber Coil Dimensions

Coil	Rcenter (m)	Zcenter (m)	ΔZ (m)	ΔR (m)	#turns	Packing Fraction
PFAB1	0.4306	1.7565	0.06788	0.02176	48	0.561
PFAB2	0.6318	1.9259	0.06788	0.02176	48	0.561

Table 2: CHI Absorber Coil Impedances

Coil	R (mΩ)	L (mH)
PFAB1	129.7	3.93
PFAB2	190.2	6.46

Table 3: CHI Absorber Coil Electrical Ratings

Peak Current	1.0 kA
Equivalent Square Wave (ΔT=80ºC)	4.0 sec
$\int I^2(t)dt$ (ΔT=80ºC)	4×10^6 A^2-sec
Terminal to Terminal Voltage	1kV
Maximum Voltage to Ground	2kV
Hipot Voltage to Ground	5kV

Notes:

1) The above is based on a conductor cross section of 0.1875" x 0.1875" with 0.1" diameter cooling hole and 0.025" corner radius. Adjustments may have to be made based on actual as-built measurements.
2) PFAB1 is mounted on the inner VV, and can therefore see a total of 1kV from its power supply plus 1kV from CHI, total of 2kV
3) PFAB2 is mounted on the outer VV, and can therefore see a total of 1kV from its power supply plus 1kV from CHI, total of 2kV

Coil Support Structures

As shown in figure 1, PFAB1 is wound into a stainless steel ring, with cross section of ΔZ=7.3" and ΔR=2.0". The ring is welded to the flange of the center stack casing.

As shown in figure 1 and figure 4, PFAB2 is secured by 11 clamps which contain the coil between a stainless steel support ring located underneath the coil, and a set of 6 tabs located above the coil which the attach to the top side of the PF2 coil support clamps. The support ring cross section is ΔZ=0.5" and ΔR=2.5". Bolting hardware is 3/8" diameter.

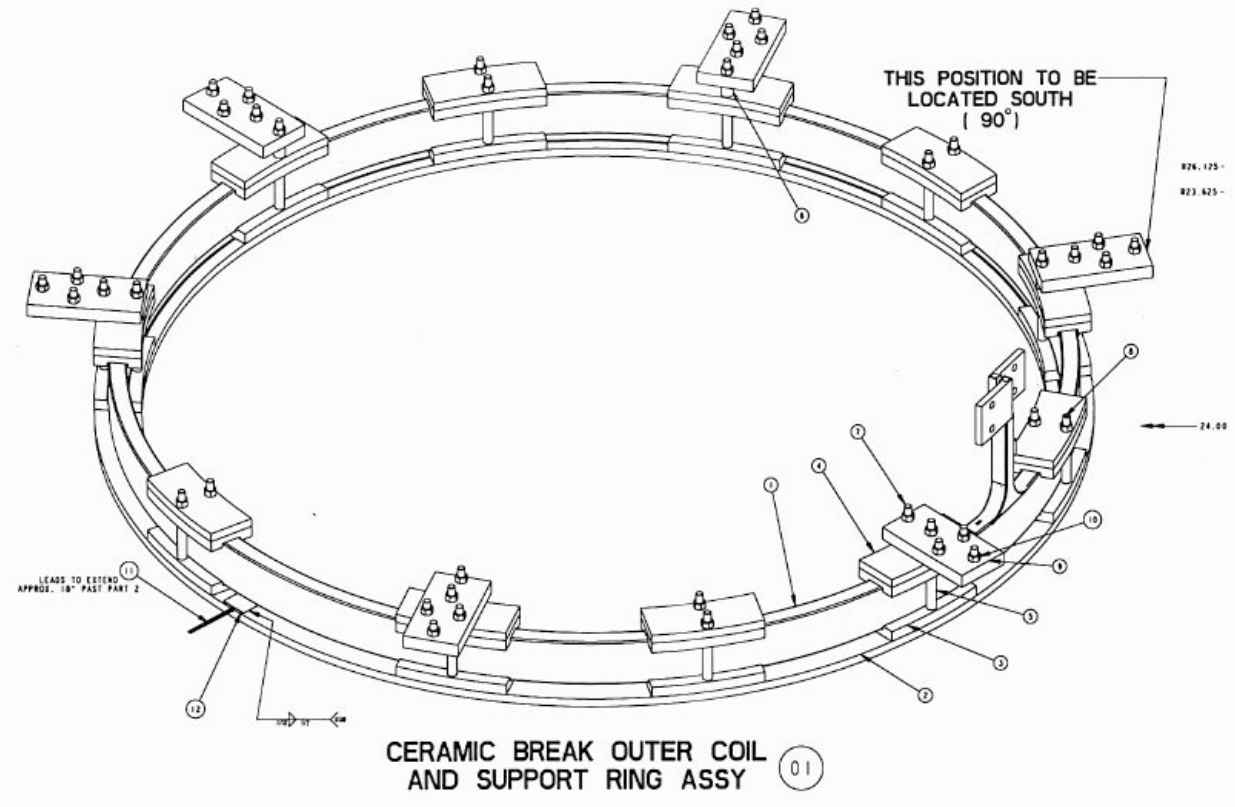

FIGURE 4: PFAB-2 Support Scheme (Dwg. E-DC1285)

Mutual Inductances

Overall NSTX PF system mutual inductance matrix including the subject coils is given in Table 4.

Table 4: PF Coil Inductances (Henry)

	OH	PF1AU	PF1AL	PF1B	PF2U	PF2L	PF3U	PF3L	PF4	PF5	PFAB1	PFAB2
OH	1.30E-02	7.31E-04	7.31E-04	3.74E-04	2.76E-04	2.76E-04	2.95E-04	2.95E-04	3.79E-04	5.28E-04	6.18E-04	4.86E-04
PF1AU	7.31E-04	3.76E-04	1.95E-07	2.25E-07	7.23E-05	1.35E-06	6.04E-05	5.29E-06	3.16E-05	4.16E-05	1.95E-04	1.22E-04
PF1AL	7.31E-04	1.95E-07	3.76E-04	9.01E-05	1.35E-06	7.23E-05	5.29E-06	6.04E-05	3.16E-05	4.16E-05	8.07E-07	1.45E-06
PF1B	3.74E-04	2.25E-07	9.01E-05	5.36E-04	1.66E-06	1.86E-04	6.61E-06	1.01E-04	4.15E-05	5.43E-05	9.69E-07	1.78E-06
PF2U	2.76E-04	7.23E-05	1.35E-06	1.66E-06	1.98E-03	1.03E-05	7.31E-04	4.11E-05	2.64E-04	3.45E-04	6.50E-04	1.84E-03
PF2L	2.76E-04	1.35E-06	7.23E-05	1.86E-04	1.03E-05	1.98E-03	4.11E-05	7.31E-04	2.64E-04	3.45E-04	5.92E-06	1.10E-05
PF3U	2.95E-04	6.04E-05	5.29E-06	6.61E-06	7.31E-04	4.11E-05	5.18E-03	1.66E-04	1.16E-03	1.49E-03	3.57E-04	7.42E-04
PF3L	2.95E-04	5.29E-06	6.04E-05	1.01E-04	4.11E-05	7.31E-04	1.66E-04	5.18E-03	1.16E-03	1.49E-03	2.35E-05	4.39E-05
PF4	3.79E-	3.16E-05	3.16E-05	4.15E-05	2.64E-04	2.64E-04	1.16E-03	1.16E-03	5.16E-03	4.81E-03	1.48E-04	2.79E-

	04											04
PF5	5.28E-04	4.16E-05	4.16E-05	5.43E-05	3.45E-04	3.45E-04	1.49E-03	1.49E-03	4.81E-03	1.23E-02	1.93E-04	3.66E-04
PFAB1	6.18E-04	1.95E-04	8.07E-07	9.69E-07	6.50E-04	5.92E-06	3.57E-04	2.35E-05	1.48E-04	1.93E-04	3.93E-03	1.33E-03
PFAB2	4.86E-04	1.22E-04	1.45E-06	1.78E-06	1.84E-03	1.10E-05	7.42E-04	4.39E-05	2.79E-04	3.66E-04	1.33E-03	6.46E-03

Coupling with PF2 and Nearby Structure

To facilitate the evaluation of the coupling effects with PF2 and nearby structure the electrical characteristics of the simplified configuration shown in Figure 5 (to scale) was modeled. Parts can be recognized by comparison with Figure 1. Dimensions are summarized in Table 5, resistances in Table 6, and mutual inductances in Table 7. Note that all of the structure is 304SS (ρ=7.7e-7Ω-m) except for the CS casing flange and ceramic insulator sealing ring which are Inconel (ρ=1.3e-6Ω-m).

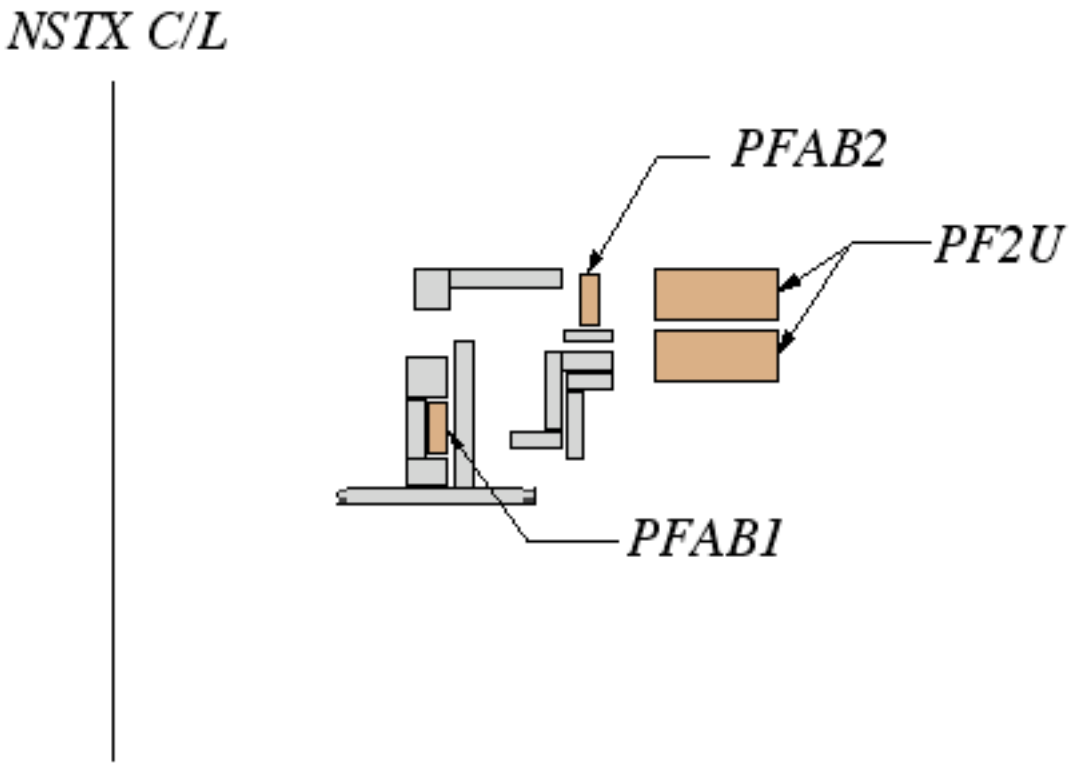

FIGURE 5: Simplified Model of absorber coils, structure, and PF2

Table 5: Dimensions

Inches....	Rcenter	Zcenter	ΔZ	ΔR
PFAB1	16.953	69.155	2.673	0.857
PFAB2	24.857	75.821	2.673	0.857
SS Ring	16.400	71.773	2.064	2.000
SS Ring	15.847	69.155	3.047	0.894
SS Ring	16.400	66.843	1.438	2.000
SS Ring	24.857	73.985	0.500	2.500
Inconel Ring	18.297	69.905	7.688	1.000
Inconel Ring	16.828	65.624	0.938	10.250
SS Ring	22.078	68.530	0.875	2.563
SS Ring	22.984	71.061	4.063	0.750
SS Ring	24.734	72.593	0.938	2.688
SS Ring	24.859	71.593	0.938	2.438
SS Ring	24.109	69.343	3.438	0.938
SS Ring	16.703	76.405	2.000	1.750
SS Ring	20.484	76.905	1.000	5.750
PF2Ua	31.464	76.123	2.676	6.406
PF2Ub	31.464	72.939	2.676	6.406
Meters....	**Rcenter**	**Zcenter**	**ΔZ**	**ΔR**
PFAB1	0.4306	1.7565	0.0679	0.0218
PFAB2	0.6314	1.9259	0.0679	0.0218
SS Ring	0.4166	1.8230	0.0524	0.0508
SS Ring	0.4025	1.7565	0.0774	0.0227
SS Ring	0.4166	1.6978	0.0365	0.0508
SS Ring	0.6314	1.8792	0.0127	0.0635
Inconel Ring	0.4647	1.7756	0.1953	0.0254
Inconel Ring	0.4274	1.6668	0.0238	0.2604
SS Ring	0.5608	1.7407	0.0222	0.0651
SS Ring	0.5838	1.8050	0.1032	0.0191
SS Ring	0.6282	1.8438	0.0238	0.0683
SS Ring	0.6314	1.8184	0.0238	0.0619
SS Ring	0.6124	1.7613	0.0873	0.0238
SS Ring	0.4243	1.9407	0.0508	0.0445
SS Ring	0.5203	1.9534	0.0254	0.1461
PF2Ua	0.7992	1.9335	0.0680	0.1627
PF2Ub	0.7992	1.8526	0.0680	0.1627

Table 6: Resistances

Element	R(Ω)
PFAB1	1.30E-01
PFAB2	1.90E-01
SS Ring	7.57E-04
SS Ring	1.11E-03
SS Ring	1.09E-03
SS Ring	3.79E-03
Inconel Ring	7.65E-04
Inconel Ring	5.63E-04
SS Ring	1.88E-03
SS Ring	1.43E-03
SS Ring	1.87E-03
SS Ring	2.07E-03
SS Ring	1.43E-03
SS Ring	9.08E-04
SS Ring	6.78E-04
PF2U	4.17E-03

Table 7: Inductance Matrix (Henry)

	PFAB1	PFAB2	SS Ring	SS Ring	SS Ring	SS Ring	Inc Ring	Inc Ring	SS Ring	SS Ring	SS Ring	SS Ring	SS Ring	SS Ring	SS Ring	PF2U
PFAB1	3.93E-03	1.33E-03	5.02E-05	6.28E-05	5.30E-05	3.05E-05	5.66E-05	3.77E-05	4.26E-05	3.80E-05	3.27E-05	3.36E-05	3.62E-05	2.62E-05	2.71E-05	6.50E-04
PFAB2	1.33E-03	6.46E-03	2.93E-05	2.39E-05	2.25E-05	1.02E-04	3.41E-05	2.21E-05	4.45E-05	6.14E-05	8.08E-05	7.13E-05	5.48E-05	3.34E-05	6.15E-05	1.83E-03
SS Ring	5.02E-05	2.93E-05	1.56E-06	1.00E-06	6.96E-07	6.50E-07	1.03E-06	5.58E-07	7.36E-07	7.47E-07	6.72E-07	6.69E-07	6.71E-07	7.39E-07	6.80E-07	1.32E-05
SS Ring	6.28E-05	2.39E-05	1.00E-06	1.51E-06	1.06E-06	5.45E-07	9.54E-07	7.33E-07	7.34E-07	6.64E-07	5.79E-07	5.92E-07	6.35E-07	5.11E-07	5.04E-07	1.17E-05
SS Ring	5.30E-05	2.25E-05	6.96E-07	1.06E-06	1.65E-06	5.22E-07	9.47E-07	1.01E-06	7.94E-07	6.62E-07	5.67E-07	5.93E-07	6.71E-07	4.06E-07	4.34E-07	1.18E-05
SS Ring	3.05E-05	1.02E-04	6.50E-07	5.45E-07	5.22E-07	2.93E-06	7.81E-07	5.22E-07	1.09E-06	1.56E-06	2.20E-06	1.87E-06	1.38E-06	6.76E-07	1.15E-06	3.88E-05
Inc Ring	5.66E-05	3.41E-05	1.03E-06	9.54E-07	9.47E-07	7.81E-07	1.37E-06	7.91E-07	1.04E-06	9.60E-07	8.31E-07	8.46E-07	8.96E-07	6.53E-07	7.05E-07	1.62E-05
Inc Ring	3.77E-05	2.21E-05	5.58E-07	7.33E-07	1.01E-06	5.22E-07	7.91E-07	1.08E-06	8.48E-07	6.70E-07	5.74E-07	6.11E-07	7.24E-07	3.53E-07	3.99E-07	1.24E-05
SS Ring	4.26E-05	4.45E-05	7.36E-07	7.34E-07	7.94E-07	1.09E-06	1.04E-06	8.48E-07	2.43E-06	1.63E-06	1.25E-06	1.37E-06	1.78E-06	5.46E-07	7.18E-07	2.42E-05
SS Ring	3.80E-05	6.14E-05	7.47E-07	6.64E-07	6.62E-07	1.56E-06	9.60E-07	6.70E-07	1.63E-06	2.33E-06	1.83E-06	1.90E-06	1.88E-06	6.45E-07	9.35E-07	2.91E-05
SS Ring	3.27E-05	8.08E-05	6.72E-07	5.79E-07	5.67E-07	2.20E-06	8.31E-07	5.74E-07	1.25E-06	1.83E-06	2.77E-06	2.39E-06	1.64E-06	6.48E-07	1.03E-06	3.74E-05
SS Ring	3.36E-05	7.13E-05	6.69E-07	5.92E-07	5.93E-07	1.87E-06	8.46E-07	6.11E-07	1.37E-06	1.90E-06	2.39E-06	2.84E-06	1.92E-06	6.16E-07	9.48E-07	3.68E-05
SS Ring	3.62E-05	5.48E-05	6.71E-07	6.35E-07	6.71E-07	1.38E-06	8.96E-07	7.24E-07	1.78E-06	1.88E-06	1.64E-06	1.92E-06	2.53E-06	5.57E-07	7.97E-07	3.08E-05
SS Ring	2.62E-05	3.34E-05	7.39E-07	5.11E-07	4.06E-07	6.76E-07	6.53E-07	3.53E-07	5.46E-07	6.45E-07	6.48E-07	6.16E-07	5.57E-07	1.64E-06	1.04E-06	1.39E-05
SS Ring	2.71E-05	6.15E-05	6.80E-07	5.04E-07	4.34E-07	1.15E-06	7.05E-07	3.99E-07	7.18E-07	9.35E-07	1.03E-06	9.48E-07	7.97E-07	1.04E-06	1.76E-06	2.27E-05
PF2U	6.50E-04	1.83E-03	1.32E-05	1.17E-05	1.18E-05	3.88E-05	1.62E-05	1.24E-05	2.42E-05	2.91E-05	3.74E-05	3.68E-05	3.08E-05	1.39E-05	2.27E-05	1.98E-03

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