CONF-8510209--4

FUSION ENGINEERING DESIGN CENTER

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SYSTEM STUDIES OVERVIEW

PRESENTED TO

U.S./JAPAN WORKSHOP

ON

NEXT STEP MACHINE DESIGN

MASTER

NAKA FUSION RESEARCH ESTABLISHMENT, JAERI

JAPAN

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SYSTEM STUDY OVERVIEW, HIGHLIGHTING

- RELATIONSHIP BETWEEN COMPACT IGNITION DEVICE AND TFCX HIGH-PERFORMANCE (HP) COPPER DEVICE

- STATUS OF CURRENT COMPACT IGNITION DEVICE SYSTEMS STUDIES

PARAMETER COMPARISON

	TFCX-HPCu	IGNITOR	ISP0424	LITE
MAJOR RADIUS (M)	2.35	1.01	1.62	1.76
MINOR RADIUS (M)	0.83	0.39	0.53	0.55
FIELD-ON-AXIS (T)	5.83	12.5	8.9	8.85
PLASMA CURRENT (MA)	8.9	9.6	7.8	7.2
BURN TIME (S)	30	0.5	5.0	5.0
FUSION POWER (MW)	244	108	305	300
WALL LOAD (MW/M^2)	2.0	4.0	5.6	4.8

HOW WAS THE TFCX-HP COPPER OPTION REDUCED FROM 2.4 M TO LESS THAN 1.8 M?

- REDUCED MISSION
- CHANGE IN APPLICATION OF ALLOWABLE STRESS
- APPLICATION OF MORE ADVENTURESOME STRUCTURAL CONCEPTS

REDUCED MISSION

- REDUCED PULSES AND BURN TIME ELIMINATED INBOARD SHIELDING REQUIREMENTS
- REDUCED PULSES ALLOW LARGER STRESSES
  $3 \times 10^5 \longrightarrow 3 \times 10^3 = 1.4 \times$
- REDUCED BURN TIME ALLOWS INERTIAL COOLING AND LARGER CURRENT DENSITIES

CHANGE IN APPLICATION OF ALLOWABLE STRESS

- AVERAGE RATHER THAN PEAK STRESS CRITERIA
  - LOCAL STRESSES WHICH ARE BEYOND YIELD WILL RESULT IN PLASTIC REDISTRIBUTION TOWARD AN AVERAGE VALUE
- 0.6 ULTIMATE STRESS IN A SELF-SUPPORTED MAGNET AND 0.7 ULTIMATE IN A CONTAINED MAGNET IN CONTRAST TO 0.33 ULTIMATE TYPICAL OF PRESSURE VESSEL BOILER CODE
- ASSUMPTION OF QUALITY CONTROL AND IN-SERVICE MONITORING OF STRUCTURAL BEHAVIOR

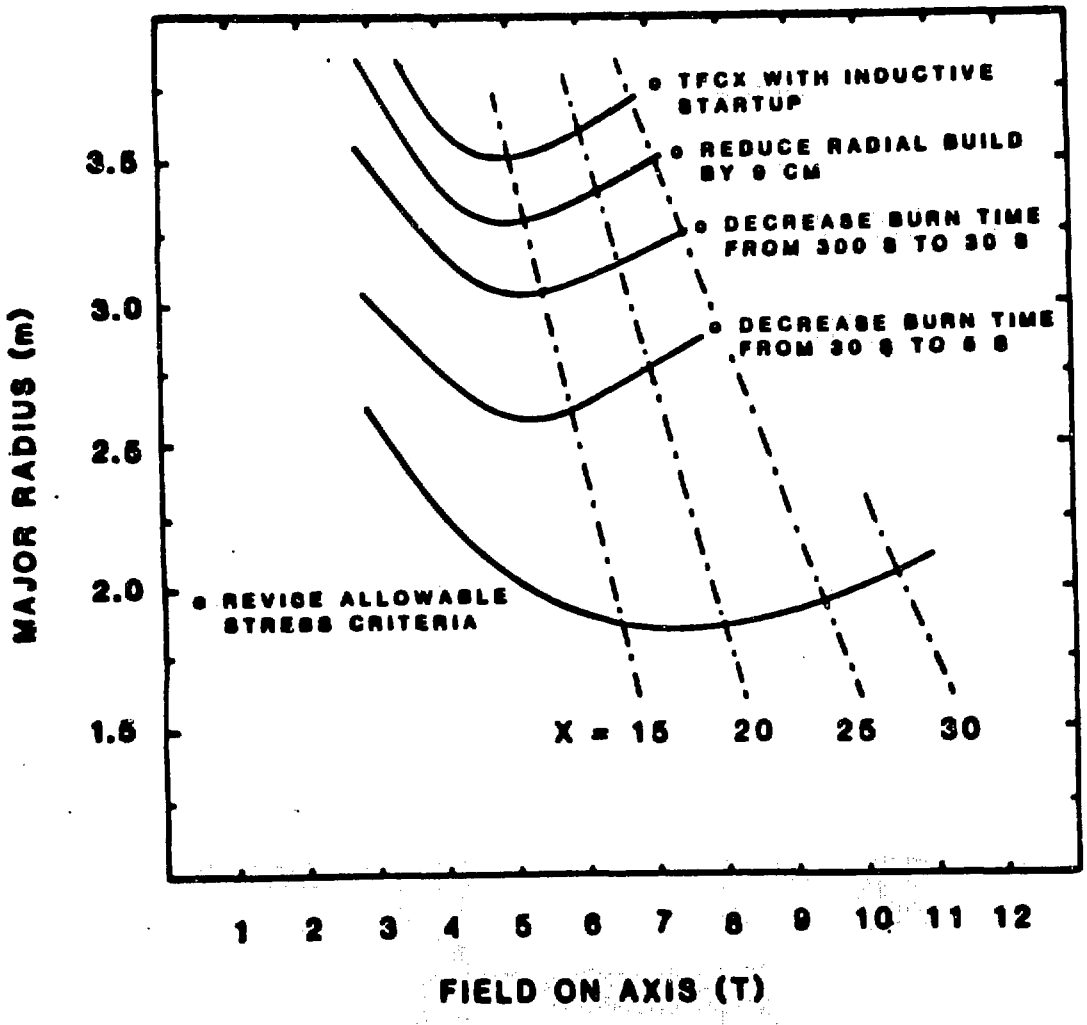
APPLICATION OF MORE ADVENTURESOME STRUCTURAL CONCEPTS

- EXTERNAL FRAME SUPPORT
- PRELOAD
- STRESS RELIEF THROUGH ADVANCED SHAPE OR SLIDING JOINTS

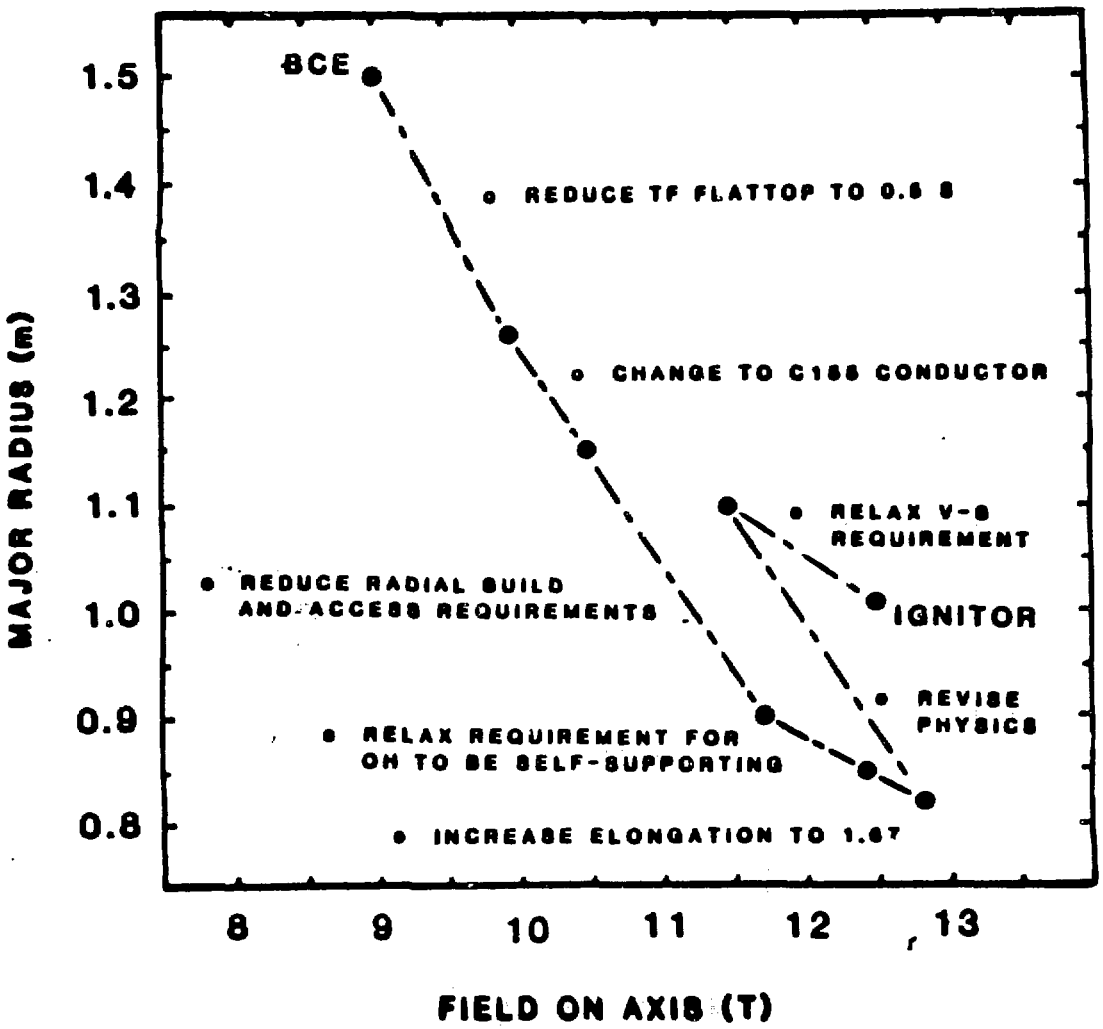
GIVEN THE CHANGE IN MISSION, NEW SYSTEM STUDIES HAVE BEEN PERFORMED TO:

- EXPLORE ALTERNATE DEVICE CONCEPTS
- TRACK IGNITION DEVICE CONCEPTS TO UNDERSTAND DIFFERENCES IN DESIGN BASES

THE COMPACTNESS OF THE LITE AND 0424 DESIGNS RELATIVE TO TFCX IS DUE TO A FEW FUNDEMENTAL DIFFERENCES IN THE DESIGN BASES



FOLLOWING THE DESIGN BASIS OF IGNITOR, A 1.15-m BE-Cu EXT. PF CONCEPT (BCE) CAN BE FURTHER REDUCED



PHYSICS DESIGN CRITERIA CONTINUE TO EVOLVE,

AND RESULTS OF ENGINEERING ANALYSIS HAVE

COMBINED TO ALTER THE PARAMETERS OF

THE CANDIDATE IGNITION DEVICES

MAJOR PHYSICS DESIGN CRITERIA

- FIGURE OF MERIT

  $X \equiv B^2 A \sqrt{K}/Q \sim 30$

- IGNITION MARGIN

  MIRNOV $\gtrsim 1.5$

  KAYE-GOLDSTON = 1.0

- BURN TIME = 10 τ_E

MAJOR ENGINEERING DESIGN CONSTRAINTS

- STRESS LIMITATIONS OF TF INNER LEG AND SOLENOIDAL COIL
- PEAK TEMPERATURE OF TF AND SOLENOID
- POWER AND ENERGY LIMITS IMPOSED BY COST CONSIDERATIONS
- VACUUM VESSEL ENVELOPE REQUIREMENT

UPDATED PARAMETERS

	IGNITOR	ISP 0424	LITE
MAJOR RADIUS, M	1.08	APPROX. 1.30	1.45
MINOR RADIUS, M	0.41		0.37
ELONGATION	1.67		1.6
TRIANGULARITY	0.2		0.3
FIELD-ON-AXIS, T	12.0		13.2
PLASMA CURRENT, MA	9.66		5.5
BETA	1.9		3.8
BURN TIME, S	1.5		5.0
FUSION POWER, MW	46		281
WALL LOAD, MW/M^2	1.6		5.1
RF POWER, MW	0		30
TOTAL V-S REQUIRED	23		24