EVALUATING FIGURE OF MERIT FOR TRITIUM BREEDING RATIO

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TBR ≡ TRITIUM BREEDING RATIO

T_R ≡ REQUIRED TBR

$$T_R = 1 + G_O + \Delta_G$$

G ≡ DOUBLING TIME MARGIN

Δ_G ≡ UNCERTAINTY IN REQUIRED G

DOUBLING TIME MARGIN

- REQUIRED TO COVER FOR:
  - LOSSES DUE TO RADIOACTIVE DECAY OF T BETWEEN PRODUCTION AND USE
  - SUPPLYING INVENTORY FOR STARTUP OF OTHER FUSION REACTORS
  - HOLD UP INVENTORY TO ACCOUNT FOR TIME DELAY BETWEEN T PRODUCTION AND USE AS WELL AS RESERVE STORAGE
- G_O IS A FUNCTION OF:
  - I ≡ TRITIUM INVENTORY (BLANKET, FUELING, STORAGE, ETC.)
  - T_D ≡ DOUBLING TIME

Δ_G ≡ UNCERTAINTY IN G_O

- EXAMPLES OF UNCERTAINTIES ARE:
  - T INVENTORY IN BLANKET
  - NECESSARY STORAGE RESERVE
  - T FRACTIONAL BURNUP IN THE PLASMA

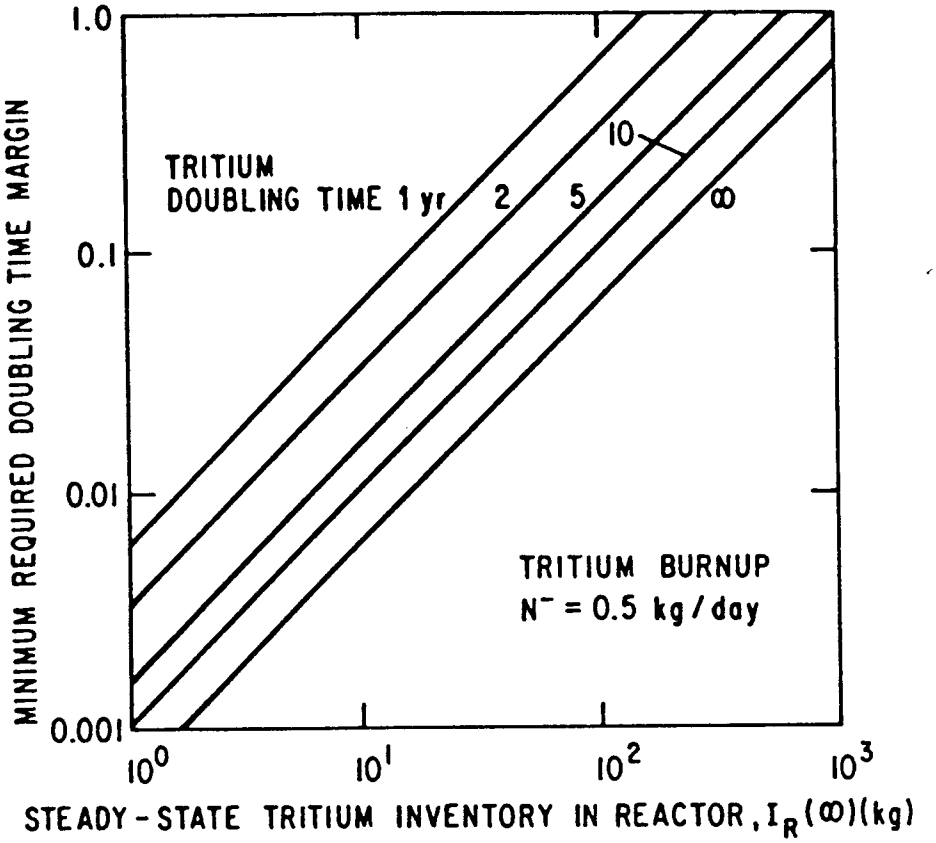

Figure III.2-2. Minimum required doubling time margin as a function reactor tritium inventory at several values of the doubling time.

$T_A \equiv$ ACHIEVABLE TBR

- PROBLEM: WE CANNOT PREDICT PRECISELY T_A BECAUSE:
  - WE DO NOT KNOW THE EXACT SPECIFICATIONS OF WHAT TO BUILD
  - FOR GIVEN REACTOR SPECIFICATIONS, WE CANNOT PREDICT PRECISELY THE PERFORMANCE

- WE CAN ONLY CALCULATE A TBR FOR A REFERENCE SYSTEM WITH ASSUMPTIONS ABOUT ITS SPECIFICATIONS

$$T_A = T_C - \sqrt{\Delta_S^2 + \Delta_P^2}$$

$T_C \equiv$ TBR CALCULATED (THE BEST WE KNOW HOW TODAY, 3D, ETC.) FOR A SPECIFIED BLANKET IN A SPECIFIED REACTOR

$\Delta_S \equiv$ UNCERTAINTY ASSOCIATED WITH <u>SYSTEM DEFINITION</u>
[CHANGES IN CALCULATED TBR RESULTING FROM CHANGES IN THE REFERENCE REACTOR SYSTEM (E.G., REFERENCE REACTOR SYSTEM HAS LIMITER AND REACTOR TO BE BUILT COULD HAVE A DIVERTOR)]

$\Delta_P \equiv$ UNCERTAINTIES IN <u>PREDICTING</u> TBR FOR A GIVEN SYSTEM

$$\Delta_P = \sqrt{\Delta_M^2 + \Delta_D^2 + \Delta_C^2}$$

$\Delta_M \equiv$ UNCERTAINTIES ASSOCIATED WITH GEOMETRIC <u>MODELING</u>

$\Delta_D \equiv$ UNCERTAINTIES ASSOCIATED WITH NUCLEAR <u>DATA</u>

$\Delta_C \equiv$ UNCERTAINTIES ASSOCIATED WITH <u>CALCULATIONAL</u> METHODS

TYPES OF UNCERTAINTIES IN PREDICTING ACHIEVABLE TBR

UNCERTAINTIES ASSOCIATED WITH SYSTEM DEFINITION (Δ_S)

- FIRST WALL/BLANKET DEFINITION
  - CONFIGURATION DETAILS, STRUCTURE, COOLANT, MANIFOLDS, FORM AND POROSITY OF SOLID BREEDERS, THERMOPHYSICAL PROPERTY VARIATIONS, ETC.
- REACTOR DEFINITION
  - TECHNOLOGY CHOICES (TYPE OF RF VS. NEUTRAL BEAMS, LIMITER VS. DIVERTOR, ETC.)
  - REQUIREMENTS AND SPEFICICATIONS FOR SPECIFIC TECHNOLOGY CHOICES (E.G., SIZE AND CONFIGURATION OF PENETRATIONS FOR LIMITER, MATERIAL CHOICES FOR LIMITER)
  - PRESENCE OF YET UNDEFINED COMPONENTS (E.G., PENETRATIONS FOR DIAGNOSTICS AND FUELING, I&C
  - POSSIBLE NEED FOR COMPONENTS TO SATISFY YET UNDEFINED REQUIREMENTS (E.G., PASSIVE COPPER COILS IN THE BLANKET FOR PLASMA STABILIZATION, SECTOR TO SECTOR ELECTRICAL JOINTS, ETC.)

$\Delta_P \equiv$ Uncertainties associated with predicting TBR for a given system

- Approximations in Geometrical Modeling (Δ_M)
  - Approximating engineering 3D surfaces and volumes by traditional mathematically convenient shapes (intersection of cones, cylinders, spheres, cubes, etc.)
  - Approximating discrete by continuous geometric zones
  - Approximating the details of heterogenity
- Nuclear Data (Δ_D)
  - Uncertainties in basic nuclear data
  - Approximations in data processing
  - Approximations in final data libraries (number of energy groups, weighting functions, etc.)
- Calculational Methods (Δ_C)
  - Inherent in methods and codes
  - Introduced by analyst (e.g., order of S_N, P_N, etc.)

PROPOSED FIGURE OF MERIT FOR TBR

$$I = \frac{T_C - (1 + G_O)}{\sqrt{\Delta_G^2 + \Delta_S^2 + \Delta_P^2}} \qquad 0 \leq I \leq 1.0$$

$T_C \equiv$ NET TBR CALCULATED FOR THE BLANKET UNDER CONSIDERATION IN 3D GEOMETRY FOR REFERENCE REACTOR CONDITIONS (E.G., MARS WITH A SET OF ASSUMPTIONS ABOUT DESIGN CHOICES; OR STARFIRE WITH SPECIFIED LIMITER, LOWER HYBRID, ETC.)

$G_O \equiv$ REQUIRED DOUBLING TIME GAIN UNDER REFERENCE CONDITIONS AND ASSUMPTIONS

$\Delta_G \equiv$ UNCERTAINTY IN PREDICTING REQUIRED DOUBLING TIME MARGIN

$\Delta_S \equiv$ UNCERTAINTY ASSOCIATED WITH SYSTEM DEFINITION

$\Delta_P \equiv$ UNCERTAINTY IN PREDICTING TBR FOR A GIVEN SYSTEM

PROCEDURE AND RESPONSIBILITIES

- EACH CONCEPT DESIGN GROUP WILL DEVELOP THE BLANKET DESIGN TO THE DEGREE OF DETAIL REQUIRED FOR CALCULATING T_C
- JUNG (WITH ASSISTANCE FROM OTHERS) WILL CALCULATE T_C FOR TOKAMAKS
- T_C FOR MIRRORS WILL BE CALCULATED BY: ? AND GORDON
- UNCERTAINTY TERMS WILL BE EVALUATED FOR EACH CONCEPT FOR BOTH MIRRORS AND TOKAMAKS:

Δ_G	JUNG
Δ_S	GOHAR/JUNG/SHIN/ABDOU
Δ_M	SHIN/ABDOU/JUNG
Δ_D	YOUSSEF
Δ_C	GOHAR/JUNG/YOUSSEF/ABDOU