PROPERTY OF CAMERON	DRAWN BY John Corkhill	DATE January 21st, 2008	REVISION	EB 702 D
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SHEARING CAPABILITIES OF CAMERON SHEAR RAMS

Introduction

This bulletin has been developed to assist Cameron equipment users in defining the shearing requirements for drilling operations. It has been revised to incorporate the latest available data that Cameron has. Product Advisory #12114 (see page 10) has also been issued to notify these users that this bulletin has been revised.

Cameron has performed extensive testing to validate & investigate the shearability of drilling tubulars using various shear ram and operator configurations. From the current physical data obtained, Cameron has derived a method that can be used as a guide to predicting if a tubular is shearable or not.

It should be noted that drilling tubular material specifications allow for large variances in mechanical properties and dimensions. Therefore, this document should be used as a guide only. The geometric values in step 1 are based upon the geometrical shapes of the tubular and rams, and testing is always encouraged to validate the sealing and shearing capabilities of the ram. **Whenever possible the largest feasible shearing capacity configuration should be selected to optimize the factor of safety in performing the shear.**

The method uses the following variables:

1) Operator configuration & dimensions for specific BOP sizes
In order to meet industry requirements, Cameron has a range of BOP shearing configurations to offer for different BOPs. The range of BOP configurations are as follows:
SB = Standard Shear Bonnet
LB = Large Bore Bonnets
SBT = Standard Shear Bonnet equipped with booster assembly
LBT = Large bore Shear Bonnet equipped with booster assembly
SS = Super Shear

2) Ram design
Cameron offers the following ram designs:
SBR = Shearing Blind Ram
DS = "DS" Style Shear Ram
ISR = Interlocking Shear Ram
DVS & CDVS = Double V Shear ram design
DSI = Dual String interlocking Shear ram design
SS = Super Shear

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3) Pipe mechanical properties
The following common material grades are considered:
Grade S = API S135 (minimum yield strength is 135000 PSI)
Grade G = API G105 (minimum yield strength is 105000 PSI)
Grade X = API X95 (minimum yield strength is 95000 PSI)
Grade E = API E75 (minimum yield strength is 75000 PSI)
Grade L80 = L80 (minimum yield strength is 80000 PSI)
Grade P110 = P110 (minimum yield strength is 110000 PSI)
Grade Q125 = Q125 (minimum yield strength is 125000 PSI)

4) Pipe geometry
The method of calculation uses the pipe weight per foot **(ppf)**. Please note that the **nominal** value is used (also known as the adjusted weight), not the plain end weight, or the weight that includes the tool joints. This value is required to account for the pipe area that is required to be sheared. Also, the tubular outside diameter and wall thickness has to be considered for the shear ram design.

5) Wellbore pressure ($P_{wellbore}$)
The presence of any wellbore pressure at the time of the shearing taking place will exert a resisting force against the piston rod that shall reduce the effective closing force of the shear ram assembly against the tubular.

6) Maximum allowable wellbore pressure
The operators have a maximum allowable working pressure.

Contact Cameron Engineering if there are any questions regarding the shearing capacity of a specific ram shearing application.

For additional information on Cameron shear rams, refer to E.B. 538 D "Shearing Blind Rams - Operation, Care, and Maintenance" or E.B. 700 D "Cameron 'DS' Shear Rams - Operation, Care, and Maintenance".

Method of Calculation

Step 1 : Confirm that the tubular is geometrically feasible to shear with the BOP shearing configuration under consideration. Table 1 details the maximum tubular OD and wall thickness restrictions for Cameron BOP ram designs. If the tubular does not exceed the maximum wall thickness and maximum diameter specified, **proceed to step 2.** If the tubular does not meet these requirements, it is deemed to be geometrically **not shearable** for that BOP ram type.

BOP TYPE	RAM TYPE	MAX. WALL THICKNESS (IN)	MAXIMUM DIAMETER (IN)
7 1/16 3-15M U/UM BOP	SBR	N/A	3.82
	DVS	.59	3.86
	DSI	*	4.50
7 1/16 10M C BOP	DSI	*	4.50
11 5-10M U BOP	SBR	.41	5.02
	DS	*	5.80
11 15M U BOP	SBR	.46	5.02
13 5/8 5-10M U/UM BOP	SBR	.46	6.28
	DS	*	7.53
	ISR	*	7.53
13 5/8 15M U/UM BOP	SBR	.46	6.28
16 5-10M U BOP	SBR	.55	8.52
18 3/4 10M U BOP	SBR	.55	8.84
20 3/4-3M 21 1/4-2M U BOP	SBR	**	10.26
21 1/4 5-10M U BOP	SBR	.59	8.91
18 3/4 10/15M UII BOP	SBR	.42	9.70
	CDVs	.73	11.75
13 5/8 10M T/TL BOP	SBR	.52	6.29
18 3/4 5/10M T/TL BOP	DVS	.77	10.50
18 3/4 15M T/TL BOP	SBR	.56	9.70
	DVS	.55	10.50
	CDVs	.73	11.75
	SUPER SHEAR (TL ONLY)	*	16.75

* No fold over mechanism on ram assembly, therefore there is no maximum wall thickness requirement. If the tubular does not excees the max. diameter requirement, proceed to step 2.
** No fold over mechanism. User is required to shear, then open to allow the fish to drop, and then close.

Table 1 : Tubular Geometric Requirements

Step 2: If the tubular meets the requirements of **STEP 1**, the required Operator shear pressure can then be calculated as follows:

$$P_{shear} := \left[\frac{(C_3 \cdot ppf \cdot \sigma_{yield})}{C_1}\right]$$ **Equation 1**

Where:
P_{shear} is the calculated required operator shear pressure (psi)

C_1 is the BOP/Operator constant obtained from **Table 2** (Page 6). This corresponds to the piston closing area (in^2).

C_3 is the Shear ram type/pipe grade constant from **Table 3** (Page 7). This is an empirical constant obtained from laboratory testing with various pipe grades and ram types.

σ_{yield} is the minimum yield strength of the tubular material.

ppf is the nominal weight of the tubular (pounds per foot)

If there is any wellbore pressure effects existing at the time of the shear (e,g created by kick pressures or drilling fluid weight) a larger shear pressure is required to overcome the opposing force created. The calculated shear pressure required shall then be:

$$P_{shear} := \left[\frac{(C_3 \cdot ppf \cdot \sigma_{yield}) + (P_W \cdot C_2)}{C_1}\right]$$ **Equation 2**

Where:
P_w is the wellbore pressure at the time of the shear (PSI)

C_2 is the BOP/Operator constant obtained from **Table 2** (Page 6). This corresponds to the Operator piston rod opening area (in^2).

A calculation sheet for equations 1 & 2 is provided on Pages 8 & 9 respectively.

EXAMPLE:
Calculate the required shearing pressure to shear 5" 19.5 ppf S135 drillpipe using an 18"-10M UBOP equipped with SBR rams and large bore tandem boosters (LBT operator designation). The shear has to take place with 3000 psi wellbore pressure.

STEP 1 : calculate if the tubular is geometrically capable of being sheared.
The nominal wall thickness of all 5" 19.5 ppf drillpipe is .36".
From **Table 1** the maximum allowable wall thickness of the tubular is .55", and the maximum allowable diameter is 8.84".

Therefore the tubular is calculated to be geometrically shearable, and you can proceed to Step 2.

STEP 2 : calculate the required shearing force.
*note: since there is a wellbore effect, use equation 2.

From Table 2, C_1=546 & C_2=31
From Table 3, C_3=.23
ppf = 19.5 lbs/ft
σ_{yield} = 135,000 psi
P_w = 3,000 psi

From Equation 2

$$P_{shear} := \frac{(.23 \cdot 19.5 \cdot 135000) + (3000 \cdot .31)}{546}$$

Therefore P_{shear} is calculated to be 1279 psi.

Note: If the shear pressure requires to be calculated using the pipe outside and inside diameter, equation 1 becomes:

$$P_{shear} := \left[\frac{\left[\left(C_3 \cdot \sigma_{yield}\right) \cdot \left(pipe_{OD}^2 - pipe_{ID}^2\right) \cdot 2.92\right]}{C_1}\right]$$

And equation 2 becomes:

$$P_{shear} := \left[\frac{\left[\left(C_3 \cdot \sigma_{yield}\right) \cdot \left(pipe_{OD}^2 - pipe_{ID}^2\right) \cdot 2.92\right] + P_w \cdot C_2}{C_1}\right]$$

Where:
$pipe_{OD}$ is the pipe outside diameter (in)
$pipe_{ID}$ is the pipe outside diameter (in)

BOP Type	Operator Type	Constant, C1	Constant, C2
7-3M THRU 15M U BOP	SB	37	6
7-3M THRU 15M U BOP	SBT	75	6
7-3M THRU 15M UL/UM BOP	SB	63	6
7-3M THRU 15M UL/UM BOP	SBT	101	6
11-3M THRU 10M U BOP	SB	65	9
11-3M THRU 10M U BOP	SBT	146	9
11-3M THRU 10M U BOP	LB	107	9
11-3M THRU 10M U BOP	LBT	188	9
11-15M U BOP	SB	88	9
11-15M U BOP	SBT	176	9
11-15M U BOP	LB	136	9
11-15M U BOP	LBT	224	9
11-5M/10M UL/UM BOP	SB	114	9
11-15M UM BOP	SB	110	13
11-15M UM BOP	SBT	194	13
13-3M/10M U BOP	SB	88	13
13-3M/10M U BOP	SBT	176	13
13-3M/10M U BOP	LB	136	13
13-3M/10M U BOP	LBT	224	13
13-15M U BOP	SB	133	13
13-15M U BOP	SBT	266	13
13-15M U BOP	LB	203	13
13-15M U BOP	LBT	336	13
13-10M UM BOP	SB	110	13
13-10M UM BOP	SBT	198	13
13-10M TL BOP	SB	157	16
16-5M/10M U BOP	SB	133	20
16-5M/10M U BOP	SBT	219	20
16-5M/10M U BOP	LB	203	20
16-5M/10M U BOP	LBT	290	20
18-10M U BOP	SB	228	31
18-10M U BOP	SBT	458	31
18-10M U BOP	LB	317	31
18-10M U BOP	LBT	546	31
18-10M UII BOP	SB	242	36
18-10M UII BOP	SBT	472	36
18-10M UII BOP	LB	309	36
18-10M UII BOP	LBT	539	36
18-15M UII BOP	SB	271	36
18-15M UII BOP	LB	334	36
18-5M/10M TL BOP (ST LOCK/MANUAL)	SB	203	20
18-5M/10M TL BOP (RAMLOCK)	SB	216	20
18-5M/10M TL BOP (RAMLOCK)	SBT	293	20
18-15M T/TL BOP (ST LOCK/MANUAL)	SB	230	36
18-15M T/TL BOP (ST LOCK/MANUAL)	SBT	475	36
18-15M TL BOP SUPERSHEAR	SS	615	36
18-15M T/TL BOP (RAMLOCK)	SB	254	36
18-15M T/TL BOP (RAMLOCK)	SBT	394	36
18-15M T BOP	LB	297	36
20-3M & 21-2M U BOP	SB	88	13
20-3M & 21-2M U BOP	SBT	175	13
20-3M & 21-2M U BOP	LB	136	13
20-3M & 21-2M U BOP	LBT	223	13
21-5M & 10M U BOP	SB	256	36

Table 2 : BOP/Operator Constants For Equation 1

Ram Type	Pipe Grade	Constant C3
SBR	E75	.33
	L80	.31
	X95	.30
	G105, P110 & Q125	.24
	S135	.23
DS, ISR, DSI, DVS, CDVS, SS	E75	.28
	L80	.26
	X95	.25
	G105, P110 & Q125	.22
	S135	.19

Table 3 : Pipe Ram/Tubular Material Constants For Equation 1

Review of Calculated Results

The required calculated shear pressure should not exceed the maximum allowable working pressure of the operator. The calculated shear pressure is a maximum predicted value based upon Camerón laboratory testing. Large variances in actual shear pressures are a consequence of the tubular manufacturer's allowable variance in the mechanical properties and significant dimensional tolerances. For this reason Cameron would always promote the user to:

A)perform actual shear testing on site to confirm the shearabilty of the tubular in question.

B)select the largest feasible shearing capacity configuration to optimize the probability of success in performing the shear.

Contact Cameron Engineering if there any questions concerning this Bulletin.

Required Shear Pressure Calculation Worksheet For Equation 1
(No Wellbore Pressure Effects)

IMPORTANT : ENSURE TUBULAR MEETS THE RERQUIREMENTS OF STEP 1 (PAGE 3) BEFORE PROCEEDING TO THE CALCULATIONS

BOP TYPE ________________ e.g 18-10M UBOP (REF. Table 2)

OPERATOR TYPE ________________ e.g SBT (REF. Table 2)

MAXIMUM ALLOWABLE OPERATING PRESSURE OF OPERATOR ________________ e.g 3000 psi

TUBULAR TYPE ________________ e.g 5" 19.5 ppf S135

C_1 = ________________ From Table 2 on page 6

C_3 = ________________ From Table 3 on page 7

ppf = ________________ Specified (lbf/ft)

σ_{yield} = ________________ Minimum yield strength (psi) (reference section 3 on page 2)

Calculated Shear Pressure, P_{shear} is given by :

$$P_{shear} := \left[\frac{(C_3 \cdot ppf \cdot \sigma_{yield})}{C_1} \right]$$

P_{shear} = ________________ Operator shear pressure (psi)

Note: P_{shear} required to be less than the maximum allowable operator pressure

Required Shear Pressure Calculation Worksheet For Equation 2 (Wellbore Pressure Effects Present)

IMPORTANT : ENSURE TUBULAR MEETS THE RERQUIREMENTS OF STEP 1 (PAGE 3) BEFORE PROCEEDING TO THE CALCULATIONS

BOP TYPE ____________ e.g 18-10M UBOP (REF. Table 2)

OPERATOR TYPE ____________ e.g SBT (REF. Table 2)

MAXIMUM ALLOWABLE OPERATING PRESSURE OF OPERATOR ____________ e.g 3000 psi

TUBULAR TYPE ____________ e.g 5" 19.5 ppf S135

C_1 = ____________ From Table 2 on page 6

C_2 = ____________ From Table 2 on page 6

C_3 = ____________ From Table 3 on page 7

ppf = ____________ specified (lbf/ft)

σ_{yield} = ____________ minimum yield strength (psi) (reference section 3 on page 2)

P_w = ____________ wellbore pressure (psi)

Calculated Shear Pressure, P_{shear} is given by :

$$P_{shear} := \left[\frac{\left(C_3 \cdot ppf \cdot \sigma_{yield}\right) + \left(P_w \cdot C_2\right)}{C_1}\right]$$

P_{shear} = ____________ Operator shear pressure (psi)

Note: P_{shear} required to be less than the maximum allowable operator pressure

21st June 2007

Product Advisory: # 12114
EB 702D Update Regarding Shearing Capabilities of Cameron Shear Rams

The purpose of this Product Advisory is to notify Cameron equipment users that Engineering Bulletin EB 702 D "Shearing Capabilities of Cameron Shear Rams" has been updated to provide the most up to date shearing information that Cameron has, regarding the shearability of drilling tubulars. Drill pipe specifications allow for large potential variances in mechanical and dimensional properties. Consequently, there is a large variance in the shear force requirement for a given drill pipe specification. Variances in the material strength, ductility, and thickness have a significant impact on the required shear force. This bulletin has been updated to address this issue.

Example; the required shearing pressure for 5" 19.5 ppf S135 grade pipe has been recorded to be as low as 2250 PSI and as high as 3540 PSI using the same BOP and operator configuration.

As can be seen, there is a significant variance of 57% in this example. Since there are numerous methods used in the industry to calculate the required shear pressure, it is very important for the BOP equipment user to understand if the shear pressure value supplied is a **minimum**, **average**, or **maximum** predicted value. When the basis of the shear pressure value is understood, a fact based decision on the required BOP shearing equipment can be made.

Cameron has performed extensive testing over the years to validate and investigate if a tubular is shearable with a given BOP operator configuration. In response to the large variances that have been experienced with required shear pressures, Cameron has performed a complete review of Cameron shear test data. EB 702 D has been updated to incorporate a shear pressure predicting formula that generates a shear pressure value. This value is derived from the **maximum** recorded shear force that Cameron has experienced in a test environment for a given drilling tubular size and material designation.

Please review the most current version of EB 702 D when selecting a suitable BOP shearing configuration for your drilling operations. Selecting an unsuitable BOP shearing configuration could result in substantial injury to persons or property.

Contact Cameron Engineering if you have any questions regarding the shearing capacity for a specific application.

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