
IS
NASA

1
00:00:20,310 --> 00:00:17,590
okay uh

2
00:00:23,269 --> 00:00:20,320
some of the other methods of direct

3
00:00:25,189 --> 00:00:23,279
reading of fastener tension

4
00:00:27,349 --> 00:00:25,199
load cells

5
00:00:29,269 --> 00:00:27,359
and of course this

6
00:00:31,509 --> 00:00:29,279
pli

7
00:00:33,830 --> 00:00:31,519
preliminar or preload indicating washer

8
00:00:36,069 --> 00:00:33,840
that i described in the washer section

9
00:00:38,229 --> 00:00:36,079
is a mechanical load cell assembly and

10
00:00:39,830 --> 00:00:38,239
those can be used

11
00:00:40,950 --> 00:00:39,840
but of course in a lot of assemblies you

12
00:00:43,110 --> 00:00:40,960
don't have room enough to put all that

13
00:00:44,630 --> 00:00:43,120

stuff in

14
00:00:46,310 --> 00:00:44,640
because the amount of deformation in

15
00:00:48,150 --> 00:00:46,320
them has been correlated to specific

16
00:00:50,709 --> 00:00:48,160
tension load in the bolt

17
00:00:53,590 --> 00:00:50,719
now the skidmore will helm bolt tension

18
00:00:55,670 --> 00:00:53,600
measuring machine

19
00:00:57,670 --> 00:00:55,680
shown on the next page has a load cell

20
00:01:00,069 --> 00:00:57,680
in it to give a direct bolt tension

21
00:01:02,069 --> 00:01:00,079
reading for an applied torque now it's a

22
00:01:04,390 --> 00:01:02,079
bench top type

23
00:01:06,550 --> 00:01:04,400
uh setup which can be

24
00:01:09,190 --> 00:01:06,560
used at a construction site you just

25
00:01:10,830 --> 00:01:09,200
clamp it on to a beam and check some

26
00:01:13,350 --> 00:01:10,840
bolts and then you

27
00:01:15,830 --> 00:01:13,360
determine the torque that you want to

28
00:01:24,070 --> 00:01:15,840
put in that particular batch of bolts

29
00:01:29,749 --> 00:01:27,990
this company is uh here in uh cleveland

30
00:01:35,749 --> 00:01:29,759
uh

31
00:01:37,670 --> 00:01:35,759
here

32
00:01:39,270 --> 00:01:37,680
see it's a little job it just has the

33
00:01:41,590 --> 00:01:39,280
the clamps over here that you can clamp

34
00:01:43,429 --> 00:01:41,600
it on and it gives a direct reading of

35
00:01:45,910 --> 00:01:43,439
the number of pounds that you've put

36
00:01:47,350 --> 00:01:45,920
into the bolt so it

37
00:01:49,030 --> 00:01:47,360
it is a way

38
00:01:50,789 --> 00:01:49,040

of determining

39
00:01:52,630 --> 00:01:50,799
uh torque

40
00:01:54,310 --> 00:01:52,640
now here is

41
00:01:57,590 --> 00:01:54,320
here's another one that you don't think

42
00:02:00,310 --> 00:01:57,600
of it as being a uh

43
00:02:02,069 --> 00:02:00,320
direct reading but it is and i use this

44
00:02:05,590 --> 00:02:02,079
one i'll cover it later in the rivets

45
00:02:07,990 --> 00:02:05,600
section this is a high lock rivet

46
00:02:10,229 --> 00:02:08,000
and uh

47
00:02:12,070 --> 00:02:10,239
or a lock bolt it's actually a lock bolt

48
00:02:13,990 --> 00:02:12,080
pardon me rather than a rivet

49
00:02:15,110 --> 00:02:14,000
because it the shank does not expand on

50
00:02:23,670 --> 00:02:15,120
it

51
00:02:25,910 --> 00:02:23,680
for installation and you have a hex key

52
00:02:28,150 --> 00:02:25,920
that holds it in place

53
00:02:31,910 --> 00:02:28,160
while you crank the nut on and when you

54
00:02:33,830 --> 00:02:31,920
get the nut to the proper torque limit

55
00:02:37,030 --> 00:02:33,840
it is notched here

56
00:02:39,509 --> 00:02:37,040
so that it snaps off breaks off so that

57
00:02:41,990 --> 00:02:39,519
is a self-limiting type

58
00:02:44,949 --> 00:02:42,000
that they have determined the

59
00:02:46,630 --> 00:02:44,959
right diameter for them

60
00:02:52,710 --> 00:02:46,640
so it will break off at the torque that

61
00:02:57,670 --> 00:02:54,869
now here's one that i mentioned earlier

62
00:03:00,949 --> 00:02:57,680
the the dti bolt

63
00:03:01,670 --> 00:03:00,959

and the guy who has that company was at

64
00:03:05,430 --> 00:03:01,680
our

65
00:03:06,710 --> 00:03:05,440
meetings

66
00:03:10,710 --> 00:03:06,720
this is a

67
00:03:14,229 --> 00:03:10,720
colored coated type bolt it has a

68
00:03:19,350 --> 00:03:17,509
gauge pin that's threaded inside it

69
00:03:22,470 --> 00:03:19,360
and then it has a

70
00:03:23,589 --> 00:03:22,480
an optical absorptance cell near the

71
00:03:25,830 --> 00:03:23,599
surface

72
00:03:27,190 --> 00:03:25,840
and as the cell changes thickness it

73
00:03:27,910 --> 00:03:27,200
changes color

74
00:03:29,270 --> 00:03:27,920
so

75
00:03:32,470 --> 00:03:29,280
as you

76
00:03:35,270 --> 00:03:32,480
elongate the bolt it pulls this gauge

77
00:03:37,270 --> 00:03:35,280
away from the cell

78
00:03:40,070 --> 00:03:37,280
and gives you a color-coded load

79
00:03:42,869 --> 00:03:40,080
indication so you turn the thing until

80
00:03:44,309 --> 00:03:42,879
it shows red or whatever and you're all

81
00:03:46,390 --> 00:03:44,319
right but of course

82
00:03:48,470 --> 00:03:46,400
the problem with a bolt like this you

83
00:03:50,229 --> 00:03:48,480
can imagine how expensive it is compared

84
00:03:52,550 --> 00:03:50,239
to a hardware store bolt

85
00:03:54,309 --> 00:03:52,560
and it's got to be big enough that you

86
00:03:56,710 --> 00:03:54,319
can drill the center of it to put that

87
00:04:02,070 --> 00:03:56,720
stuff in so the minimum size for it is a

88
00:04:06,710 --> 00:04:05,190

now we move on to design criteria

89
00:04:09,589 --> 00:04:06,720
and

90
00:04:12,550 --> 00:04:09,599
this first line is one of my pet peeves

91
00:04:17,189 --> 00:04:12,560
i think that we don't spend enough time

92
00:04:20,949 --> 00:04:18,870
we should think about it look at it

93
00:04:23,270 --> 00:04:20,959
first now of course working with the

94
00:04:23,990 --> 00:04:23,280
research people around here you usually

95
00:04:27,510 --> 00:04:24,000
do

96
00:04:29,189 --> 00:04:27,520
designs by an iterative process because

97
00:04:30,710 --> 00:04:29,199
when they come to you about something

98
00:04:34,550 --> 00:04:30,720
usually they don't know and i'm not

99
00:04:38,310 --> 00:04:36,710
degrading remark they don't know exactly

100
00:04:39,830 --> 00:04:38,320
what they want so they tell you what

101
00:04:41,830 --> 00:04:39,840
they think they want and then you take

102
00:04:44,390 --> 00:04:41,840
it from there and usually what happens

103
00:04:47,909 --> 00:04:44,400
is you by iterative process

104
00:04:50,150 --> 00:04:47,919
you come up with the actual requirements

105
00:04:52,469 --> 00:04:50,160
and that's something that you should do

106
00:04:54,310 --> 00:04:52,479
on any design you should sit down first

107
00:04:56,629 --> 00:04:54,320
and look at it

108
00:04:59,030 --> 00:04:56,639
decide what you really need

109
00:05:00,870 --> 00:04:59,040
and then look at the accepted design

110
00:05:02,790 --> 00:05:00,880
practices from both the layout and

111
00:05:09,270 --> 00:05:02,800
analytical standpoints

112
00:05:14,310 --> 00:05:11,270
now here's here's one of the questions

113
00:05:17,350 --> 00:05:14,320

that comes up sometimes is diameter

114
00:05:19,749 --> 00:05:17,360
versus length on fasteners

115
00:05:21,909 --> 00:05:19,759
and uh

116
00:05:24,469 --> 00:05:21,919
we're always faced with decisions on do

117
00:05:27,270 --> 00:05:24,479
you use off-the-shelf stuff

118
00:05:28,790 --> 00:05:27,280
or do you custom design it

119
00:05:31,430 --> 00:05:28,800
well

120
00:05:33,909 --> 00:05:31,440
a good way to look at it is to check and

121
00:05:35,430 --> 00:05:33,919
see what's available first see if you

122
00:05:37,510 --> 00:05:35,440
can

123
00:05:39,670 --> 00:05:37,520
build your design around that without

124
00:05:41,670 --> 00:05:39,680
having to buy special

125
00:05:42,710 --> 00:05:41,680
components

126
00:05:43,590 --> 00:05:42,720
and

127
00:05:46,310 --> 00:05:43,600
so

128
00:05:49,189 --> 00:05:46,320
one of the things that

129
00:05:50,629 --> 00:05:49,199
you look at is the length to diameter

130
00:05:51,749 --> 00:05:50,639
ratio

131
00:05:54,230 --> 00:05:51,759
of

132
00:05:55,430 --> 00:05:54,240
because if you want to use a 10 inch

133
00:05:57,350 --> 00:05:55,440
fastener that's a quarter inch in

134
00:05:58,870 --> 00:05:57,360
diameter

135
00:06:00,710 --> 00:05:58,880
and you don't want to make it out of

136
00:06:01,830 --> 00:06:00,720
threaded rod

137
00:06:05,110 --> 00:06:01,840
you're in trouble because you're going

138
00:06:08,150 --> 00:06:05,120

to have to get one that's custom made

139
00:06:10,469 --> 00:06:08,160
usually the l over d ratio is up to

140
00:06:14,629 --> 00:06:10,479
about 12

141
00:06:16,950 --> 00:06:14,639
and uh it's limited somewhat by the

142
00:06:19,909 --> 00:06:16,960
capacity of the automatic screw forming

143
00:06:21,749 --> 00:06:19,919
machines because you can't put a long

144
00:06:23,990 --> 00:06:21,759
skinny fastener through there and do it

145
00:06:28,309 --> 00:06:24,000
on an automated basis

146
00:06:29,670 --> 00:06:28,319
so we have a table here that lists

147
00:06:31,029 --> 00:06:29,680
common

148
00:06:33,029 --> 00:06:31,039
fasteners

149
00:06:34,710 --> 00:06:33,039
availability now these are industrial

150
00:06:36,629 --> 00:06:34,720
fasteners

151
00:06:37,430 --> 00:06:36,639
not aerospace

152
00:06:38,230 --> 00:06:37,440
and

153
00:06:40,309 --> 00:06:38,240
the

154
00:06:42,870 --> 00:06:40,319
one asterix

155
00:06:45,830 --> 00:06:42,880
represents the stock sizes of maximum

156
00:06:48,390 --> 00:06:45,840
demand so you see if you're in this this

157
00:06:50,230 --> 00:06:48,400
area if you need a

158
00:06:52,150 --> 00:06:50,240
3 8 diameter

159
00:06:53,990 --> 00:06:52,160
with an inch or inch and a quarter

160
00:06:56,469 --> 00:06:54,000
length you got it

161
00:06:58,550 --> 00:06:56,479
two asterisks represents the ones less

162
00:07:00,230 --> 00:06:58,560
frequently used so if you want say a

163
00:07:01,189 --> 00:07:00,240

quarter inch and an inch and three

164
00:07:03,510 --> 00:07:01,199
quarter

165
00:07:05,510 --> 00:07:03,520
length you might have a little trouble

166
00:07:06,710 --> 00:07:05,520
all the rest of them are considered

167
00:07:09,510 --> 00:07:06,720
specials

168
00:07:12,230 --> 00:07:09,520
so if you want a quarter inch

169
00:07:13,830 --> 00:07:12,240
by six inch look look how deep of

170
00:07:15,990 --> 00:07:13,840
trouble you're in down here because you

171
00:07:16,950 --> 00:07:16,000
can't get it unless you pay special for

172
00:07:20,070 --> 00:07:16,960
it

173
00:07:21,909 --> 00:07:20,080
and i know we had some

174
00:07:23,589 --> 00:07:21,919
fasteners on a job that we did here one

175
00:07:25,749 --> 00:07:23,599
time that were quarter inch stainless

176
00:07:27,749 --> 00:07:25,759
steel that had to be i believe

177
00:07:29,350 --> 00:07:27,759
six inches or five and a half inches or

178
00:07:30,950 --> 00:07:29,360
six inches long

179
00:07:33,270 --> 00:07:30,960
we had to pay special for them and took

180
00:07:35,589 --> 00:07:33,280
a long time to get them now when i say

181
00:07:38,629 --> 00:07:35,599
these are industrial type fasteners on

182
00:07:41,430 --> 00:07:38,639
the aerospace fasteners the links there

183
00:07:43,990 --> 00:07:41,440
are graduated in sixteenths

184
00:07:46,309 --> 00:07:44,000
uh the different specified dash number

185
00:07:48,790 --> 00:07:46,319
that gives you the

186
00:07:52,070 --> 00:07:48,800
grip length of the fastener in

187
00:07:53,830 --> 00:07:52,080
sixteenths but just because somebody

188
00:07:55,830 --> 00:07:53,840

shows it in their catalog doesn't mean

189
00:07:58,950 --> 00:07:55,840
that they have it either so if you need

190
00:08:01,029 --> 00:07:58,960
something that's an oddball type uh

191
00:08:04,309 --> 00:08:01,039
length to diameter you still are going

192
00:08:06,230 --> 00:08:04,319
to have to to pay special for it now

193
00:08:08,790 --> 00:08:06,240
here's a little handy dandy thing that

194
00:08:11,029 --> 00:08:08,800
uh once again i

195
00:08:12,710 --> 00:08:11,039
got it from one of these guys at martin

196
00:08:14,550 --> 00:08:12,720
when i worked there

197
00:08:17,430 --> 00:08:14,560
and i've never seen this anywhere either

198
00:08:19,430 --> 00:08:17,440
is a way of calculating the number

199
00:08:21,749 --> 00:08:19,440
fastener diameter

200
00:08:24,629 --> 00:08:21,759
i put it in my fastener manual so a lot

201
00:08:26,790 --> 00:08:24,639
of you guys have already seen it but

202
00:08:29,990 --> 00:08:26,800
in order to calculate it this is for

203
00:08:33,670 --> 00:08:30,000
inches of course you take 60 thousandths

204
00:08:35,909 --> 00:08:33,680
plus 13 thousandths times n where n is

205
00:08:39,509 --> 00:08:35,919
the number of the fastener

206
00:08:41,509 --> 00:08:39,519
and that'll give you the total od of it

207
00:08:43,990 --> 00:08:41,519
and i the example i give here is a

208
00:08:45,670 --> 00:08:44,000
number eight fastener you take sixty

209
00:08:48,389 --> 00:08:45,680
thousandths plus thirteen thousands

210
00:08:51,030 --> 00:08:48,399
times eight gives you a 164. so if

211
00:08:53,590 --> 00:08:51,040
somebody says i got a number six

212
00:08:56,230 --> 00:08:53,600
or a number four you can calculate the

213
00:08:57,430 --> 00:08:56,240

decimal diameter of it directly that way

214
00:08:59,269 --> 00:08:57,440
just by keeping that in mind of course

215
00:09:03,590 --> 00:08:59,279
the number 10 is easy

216
00:09:07,750 --> 00:09:05,350
and

217
00:09:09,990 --> 00:09:07,760
for those of you who are

218
00:09:12,710 --> 00:09:10,000
haven't seen them before they even have

219
00:09:15,670 --> 00:09:12,720
number 12 fasteners

220
00:09:17,269 --> 00:09:15,680
which is i believe works out to be 0.216

221
00:09:19,910 --> 00:09:17,279
or something like that the automotive

222
00:09:21,509 --> 00:09:19,920
industry uses them some and i ran into

223
00:09:23,829 --> 00:09:21,519
some of them one time and i couldn't

224
00:09:25,350 --> 00:09:23,839
figure out what they were way back years

225
00:09:26,870 --> 00:09:25,360
years ago until i figured out it was a

226
00:09:29,670 --> 00:09:26,880
number 12

227
00:09:32,470 --> 00:09:29,680
but they're they're not a normal one

228
00:09:34,870 --> 00:09:32,480
now clearance holes for fasteners

229
00:09:38,150 --> 00:09:34,880
for shear applications

230
00:09:41,590 --> 00:09:38,160
the clearance should be minimized

231
00:09:43,590 --> 00:09:41,600
and uh ideally the hole should be max

232
00:09:45,670 --> 00:09:43,600
drilled

233
00:09:47,030 --> 00:09:45,680
and the material thickness and fastener

234
00:09:48,870 --> 00:09:47,040
strength should be sized to make the

235
00:09:52,150 --> 00:09:48,880
fasteners critical in bearing rather

236
00:09:54,310 --> 00:09:52,160
than shear that means that if you pull

237
00:09:55,590 --> 00:09:54,320
and shear on the joint

238
00:09:57,430 --> 00:09:55,600

that the

239
00:10:00,070 --> 00:09:57,440
fastener is stronger than the material

240
00:10:02,790 --> 00:10:00,080
it's in so it will elongate the hole so

241
00:10:05,829 --> 00:10:02,800
it can load up the other fasteners

242
00:10:07,910 --> 00:10:05,839
and uh in tension applications you don't

243
00:10:09,670 --> 00:10:07,920
have to worry about that if it's if you

244
00:10:11,829 --> 00:10:09,680
can assure yourself that you have enough

245
00:10:13,350 --> 00:10:11,839
tension in it enough friction that the

246
00:10:16,230 --> 00:10:13,360
joint won't move

247
00:10:18,310 --> 00:10:16,240
then you can have a looser fit on it

248
00:10:20,550 --> 00:10:18,320
then then your main concern is prevent

249
00:10:21,990 --> 00:10:20,560
the fastener head or the nut from

250
00:10:24,550 --> 00:10:22,000
pulling through the hole or something

251
00:10:27,509 --> 00:10:24,560
like that or embedding in it now on the

252
00:10:31,750 --> 00:10:30,069
fred yaris's group was kind enough to

253
00:10:33,509 --> 00:10:31,760
draw me up this little thing because i

254
00:10:35,110 --> 00:10:33,519
couldn't find one usually you try to

255
00:10:37,509 --> 00:10:35,120
steal stuff from someplace else for

256
00:10:38,630 --> 00:10:37,519
these to save yourself work but

257
00:10:40,550 --> 00:10:38,640
uh

258
00:10:41,829 --> 00:10:40,560
we couldn't get by with it so we had to

259
00:10:44,630 --> 00:10:41,839
make one

260
00:10:47,670 --> 00:10:44,640
and this is a little

261
00:10:50,230 --> 00:10:47,680
drawing of a joint to illustrate

262
00:10:53,190 --> 00:10:50,240
the clearance hole gaps on fasteners and

263
00:10:55,750 --> 00:10:53,200

where it gets you in trouble

264
00:10:58,389 --> 00:10:55,760
now this happens a lot

265
00:11:00,310 --> 00:10:58,399
i'll go to this one over here to maybe a

266
00:11:02,710 --> 00:11:00,320
little clearer this happens a lot where

267
00:11:03,990 --> 00:11:02,720
you have two pieces

268
00:11:06,150 --> 00:11:04,000
that

269
00:11:07,990 --> 00:11:06,160
one place makes one piece and somebody

270
00:11:09,110 --> 00:11:08,000
else makes the other one then you bring

271
00:11:10,550 --> 00:11:09,120
them back and you try to put them

272
00:11:13,110 --> 00:11:10,560
together

273
00:11:14,949 --> 00:11:13,120
and this is what you get now these are

274
00:11:18,550 --> 00:11:14,959
the different gaps see

275
00:11:20,470 --> 00:11:18,560
see here we have no gap on this

276
00:11:22,550 --> 00:11:20,480
but look what we got up here and look

277
00:11:25,030 --> 00:11:22,560
what we got here

278
00:11:26,630 --> 00:11:25,040
so if you pull on that

279
00:11:30,150 --> 00:11:26,640
the only way

280
00:11:31,910 --> 00:11:30,160
that these other fasteners can load up

281
00:11:33,910 --> 00:11:31,920
like for instance here

282
00:11:35,750 --> 00:11:33,920
since that one is up against the the

283
00:11:38,069 --> 00:11:35,760
wall right now

284
00:11:40,790 --> 00:11:38,079
in order for this one to load up

285
00:11:43,190 --> 00:11:40,800
the hole has to elongate on here for

286
00:11:46,310 --> 00:11:43,200
that one to load up so

287
00:11:49,829 --> 00:11:46,320
so this is why that in a

288
00:11:51,829 --> 00:11:49,839

real shear applications critical design

289
00:11:53,990 --> 00:11:51,839
you should match drill

290
00:11:56,870 --> 00:11:54,000
and this is what the aerospace companies

291
00:11:59,990 --> 00:11:56,880
do they'll take the pieces

292
00:12:01,990 --> 00:12:00,000
they'll have a pilot hole in one

293
00:12:03,990 --> 00:12:02,000
which is a smaller diameter hole than

294
00:12:05,269 --> 00:12:04,000
the the hole that needs to be in it at

295
00:12:07,430 --> 00:12:05,279
the end

296
00:12:09,590 --> 00:12:07,440
they will clamp them together then they

297
00:12:12,550 --> 00:12:09,600
will use that pilot hole

298
00:12:14,550 --> 00:12:12,560
to go in with the proper size drill and

299
00:12:17,110 --> 00:12:14,560
drill the hole all the way through both

300
00:12:19,350 --> 00:12:17,120
pieces so that it matches perfectly

301
00:12:21,269 --> 00:12:19,360
drilled with the same drill

302
00:12:31,430 --> 00:12:21,279
and then you put it together and you

303
00:12:35,750 --> 00:12:33,670
now here here's another one that

304
00:12:38,870 --> 00:12:35,760
we can run into trouble on is mixing of

305
00:12:41,430 --> 00:12:38,880
the thread and material types and this

306
00:12:42,710 --> 00:12:41,440
happens in designs sometimes

307
00:12:45,190 --> 00:12:42,720
because

308
00:12:46,870 --> 00:12:45,200
you can have say 300 series stainless

309
00:12:49,269 --> 00:12:46,880
steel fasteners

310
00:12:51,590 --> 00:12:49,279
and you can have a286 stainless steel

311
00:12:53,430 --> 00:12:51,600
fasteners and you look at them

312
00:12:55,829 --> 00:12:53,440
they look alike

313
00:12:58,470 --> 00:12:55,839

the one has a strength of usually of 160

314
00:13:01,990 --> 00:12:58,480
and the other one has a strength of 70.

315
00:13:04,310 --> 00:13:02,000
so you can get in trouble with it so

316
00:13:07,509 --> 00:13:04,320
if the different sizes

317
00:13:09,430 --> 00:13:07,519
have fine or coarse threads on the same

318
00:13:11,590 --> 00:13:09,440
diameters or i mean if you have them

319
00:13:13,829 --> 00:13:11,600
with the same diameters with the

320
00:13:16,230 --> 00:13:13,839
finer coarse threads or metric threads

321
00:13:18,230 --> 00:13:16,240
then you're in real trouble because

322
00:13:19,750 --> 00:13:18,240
to a mechanic all these fasteners look

323
00:13:22,230 --> 00:13:19,760
alike

324
00:13:24,310 --> 00:13:22,240
and this happened on the cm1 job if i

325
00:13:25,990 --> 00:13:24,320
recall we had one that the guy couldn't

326
00:13:27,750 --> 00:13:26,000
figure out why it wouldn't go in the

327
00:13:29,670 --> 00:13:27,760
hole

328
00:13:31,350 --> 00:13:29,680
and it was a metric

329
00:13:34,230 --> 00:13:31,360
course

330
00:13:37,110 --> 00:13:34,240
when i had him get a gauge engage it and

331
00:13:39,030 --> 00:13:37,120
we had inch stuff around there too so

332
00:13:40,389 --> 00:13:39,040
and and the rest of the metric stuff was

333
00:13:42,790 --> 00:13:40,399
fine thread i think and this one

334
00:13:44,790 --> 00:13:42,800
happened to be of course so so this is

335
00:13:46,069 --> 00:13:44,800
asking for trouble because if something

336
00:13:48,870 --> 00:13:46,079
won't fit somebody's going to try to

337
00:13:50,150 --> 00:13:48,880
make it fit and they put it together

338
00:13:53,829 --> 00:13:50,160

now

339
00:13:57,430 --> 00:13:53,839
we covered the different strength levels

340
00:13:59,110 --> 00:13:57,440
and the fact that 300 series and a286

341
00:14:06,150 --> 00:13:59,120
look alike

342
00:14:08,790 --> 00:14:06,160
different platings on materials can be

343
00:14:11,670 --> 00:14:08,800
dyed to where they

344
00:14:15,430 --> 00:14:13,430
so next we go to the selection and

345
00:14:17,509 --> 00:14:15,440
positioning of the washer

346
00:14:19,189 --> 00:14:17,519
and you've got to pick washers that are

347
00:14:21,269 --> 00:14:19,199
large enough to distribute the load

348
00:14:23,110 --> 00:14:21,279
under the head or the nut

349
00:14:25,509 --> 00:14:23,120
without exceeding the compressive yield

350
00:14:27,430 --> 00:14:25,519
strength of the joint material

351
00:14:29,590 --> 00:14:27,440
so uh

352
00:14:31,189 --> 00:14:29,600
you want a hard washer and a smooth one

353
00:14:32,710 --> 00:14:31,199
so that you can you know what your

354
00:14:34,790 --> 00:14:32,720
coefficient of friction

355
00:14:36,949 --> 00:14:34,800
is going to be

356
00:14:38,790 --> 00:14:36,959
and if the internal diameter the washer

357
00:14:41,189 --> 00:14:38,800
is much larger than the fastener then

358
00:14:43,110 --> 00:14:41,199
you better try to try to center it

359
00:14:45,030 --> 00:14:43,120
to make sure that they will fit don't do

360
00:14:46,470 --> 00:14:45,040
one of those deals like i've seen people

361
00:14:47,910 --> 00:14:46,480
do before where they stack up a whole

362
00:14:49,590 --> 00:14:47,920
bunch of washers

363
00:14:51,509 --> 00:14:49,600

and then they got to jiggle them around

364
00:14:52,710 --> 00:14:51,519
to get them to fit

365
00:14:54,870 --> 00:14:52,720
under the head

366
00:14:56,230 --> 00:14:54,880
and you might wind up with with the

367
00:14:58,069 --> 00:14:56,240
thing

368
00:15:02,389 --> 00:14:58,079
embedding in the material on one side

369
00:15:08,550 --> 00:15:05,590
now shear loads on a fastener group

370
00:15:12,069 --> 00:15:08,560
this is something that i i gave you

371
00:15:14,550 --> 00:15:12,079
a lot of verbiage on this to help you go

372
00:15:17,269 --> 00:15:14,560
through the stuff on your own

373
00:15:19,590 --> 00:15:17,279
and uh so i'll just kind of hit the the

374
00:15:21,189 --> 00:15:19,600
highlights on this number one on where

375
00:15:23,110 --> 00:15:21,199
you have a pattern of fasteners the

376
00:15:25,269 --> 00:15:23,120
first thing you want to do is determine

377
00:15:27,829 --> 00:15:25,279
the centroid of the pattern but pick

378
00:15:29,030 --> 00:15:27,839
picking x and y axes and using unit

379
00:15:32,310 --> 00:15:29,040
areas

380
00:15:33,110 --> 00:15:32,320
times its distance to get the centroid

381
00:15:34,949 --> 00:15:33,120
and

382
00:15:37,430 --> 00:15:34,959
although it's not a good idea to have

383
00:15:39,110 --> 00:15:37,440
fasteners of a different diameter

384
00:15:41,749 --> 00:15:39,120
you can

385
00:15:43,829 --> 00:15:41,759
use them in this type of analysis by

386
00:15:46,310 --> 00:15:43,839
ratioing the diameters

387
00:15:48,550 --> 00:15:46,320
for instance the one i gave here if i

388
00:15:50,230 --> 00:15:48,560

had eight bolts of a 12-volt pattern

389
00:15:52,829 --> 00:15:50,240
that were three-eighths and the other

390
00:15:56,949 --> 00:15:52,839
four or five-sixteenths

391
00:15:58,550 --> 00:15:56,959
uh you can ratio the shank diameters and

392
00:16:00,230 --> 00:15:58,560
you use

393
00:16:05,269 --> 00:16:00,240
one

394
00:16:07,350 --> 00:16:05,279
and use the the stress ratios then to

395
00:16:08,389 --> 00:16:07,360
give you a factor for the other one to

396
00:16:10,550 --> 00:16:08,399
use

397
00:16:11,430 --> 00:16:10,560
this way you can calculate

398
00:16:18,629 --> 00:16:11,440
the

399
00:16:21,350 --> 00:16:19,749
uh

400
00:16:24,870 --> 00:16:21,360
in a lot of cases you'll have a

401
00:16:26,230 --> 00:16:24,880
symmetrical pattern so you're okay

402
00:16:27,030 --> 00:16:26,240
and uh

403
00:16:29,430 --> 00:16:27,040
but

404
00:16:32,150 --> 00:16:29,440
after you find the the centroid then you

405
00:16:35,189 --> 00:16:32,160
can get these sigma r squares for the

406
00:16:37,749 --> 00:16:35,199
for the fasteners which will give you an

407
00:16:39,829 --> 00:16:37,759
equivalent moment of inertia if you will

408
00:16:40,790 --> 00:16:39,839
like like calculating bending stresses

409
00:16:42,949 --> 00:16:40,800
so

410
00:16:45,749 --> 00:16:42,959
uh we can move over to the figure and i

411
00:16:48,710 --> 00:16:45,759
think i can talk you through that better

412
00:16:52,069 --> 00:16:48,720
uh here is a a bracket

413
00:16:53,590 --> 00:16:52,079

that has a an eccentric load on it here

414
00:16:55,590 --> 00:16:53,600
are

415
00:16:57,350 --> 00:16:55,600
okay now to get

416
00:16:59,590 --> 00:16:57,360
and it's loaded just in shear we're not

417
00:17:00,790 --> 00:16:59,600
putting any tension on it

418
00:17:03,829 --> 00:17:00,800
so

419
00:17:06,470 --> 00:17:03,839
we have to transfer that to the cg of

420
00:17:08,230 --> 00:17:06,480
course remember in strength of materials

421
00:17:10,949 --> 00:17:08,240
you transfer a load

422
00:17:13,350 --> 00:17:10,959
to the cg you have a

423
00:17:14,789 --> 00:17:13,360
direct load and a moment is what you

424
00:17:15,590 --> 00:17:14,799
replace it with

425
00:17:19,990 --> 00:17:15,600
so

426
00:17:21,990 --> 00:17:20,000
just taking r and divide it by the

427
00:17:23,590 --> 00:17:22,000
number of fasteners that gives you a

428
00:17:25,750 --> 00:17:23,600
load there

429
00:17:28,309 --> 00:17:25,760
now you get a moment

430
00:17:30,789 --> 00:17:28,319
r times this value e

431
00:17:32,870 --> 00:17:30,799
which you have to react now the way that

432
00:17:35,909 --> 00:17:32,880
you react that

433
00:17:37,510 --> 00:17:35,919
you take these r values

434
00:17:39,270 --> 00:17:37,520
which is the distance this is the

435
00:17:40,230 --> 00:17:39,280
centroid since it's a symmetrical

436
00:17:43,190 --> 00:17:40,240
pattern

437
00:17:45,270 --> 00:17:43,200
so you have four r values measured here

438
00:17:46,390 --> 00:17:45,280

here here and here

439
00:17:47,909 --> 00:17:46,400
that are the same

440
00:17:50,549 --> 00:17:47,919
and then you have four more that are the

441
00:17:53,190 --> 00:17:50,559
same from here to here from here to here

442
00:17:55,270 --> 00:17:53,200
up to there and down to here so now you

443
00:17:59,110 --> 00:17:55,280
take those and add them up so you have

444
00:18:02,950 --> 00:17:59,120
four times r one squared

445
00:18:05,750 --> 00:18:02,960
plus 4 times r2 squared and that gives

446
00:18:07,270 --> 00:18:05,760
you your equivalent moment of inertia if

447
00:18:09,990 --> 00:18:07,280
you will

448
00:18:12,150 --> 00:18:10,000
then you can find a load on the fastener

449
00:18:13,270 --> 00:18:12,160
by taking the moment

450
00:18:14,390 --> 00:18:13,280
times

451
00:18:25,510 --> 00:18:14,400
the

452
00:18:26,549 --> 00:18:25,520
value that you calculated using uh those

453
00:18:28,710 --> 00:18:26,559
values

454
00:18:30,310 --> 00:18:28,720
and you come up with another load now

455
00:18:32,870 --> 00:18:30,320
you take those two

456
00:18:34,950 --> 00:18:32,880
since they're both in the shear plane

457
00:18:37,350 --> 00:18:34,960
you combine them vectorially to get a

458
00:18:40,470 --> 00:18:37,360
resultant load p

459
00:18:42,470 --> 00:18:40,480
for a total shear load on the fastener

460
00:18:45,270 --> 00:18:42,480
then of course that takes care of the

461
00:18:48,470 --> 00:18:45,280
the shear loads

462
00:18:50,630 --> 00:18:48,480
now if if you look at this value this

463
00:18:53,270 --> 00:18:50,640

also would correspond to like a

464
00:18:56,870 --> 00:18:53,280
torsional formula the tr over j in which

465
00:18:58,630 --> 00:18:56,880
the sigma sigma r squared is the r sub n

466
00:19:00,870 --> 00:18:58,640
squared is the equivalent of a polar

467
00:19:02,710 --> 00:19:00,880
moment of inertia j

468
00:19:05,110 --> 00:19:02,720
except that the load that you get here

469
00:19:07,029 --> 00:19:05,120
is in pounds

470
00:19:10,390 --> 00:19:07,039
and so

471
00:19:12,230 --> 00:19:10,400
so then later on if we have tension on

472
00:19:15,029 --> 00:19:12,240
on something like this

473
00:19:17,830 --> 00:19:15,039
we can combine it

474
00:19:19,669 --> 00:19:17,840
and get the total load

475
00:19:21,430 --> 00:19:19,679
using stress ratios

476
00:19:22,789 --> 00:19:21,440
now on edge distance and fastener

477
00:19:24,390 --> 00:19:22,799
spacing this is something that's

478
00:19:27,029 --> 00:19:24,400
violated a lot

479
00:19:28,390 --> 00:19:27,039
in fact we put out designs around here

480
00:19:29,590 --> 00:19:28,400
before

481
00:19:31,110 --> 00:19:29,600
that

482
00:19:33,110 --> 00:19:31,120
i have

483
00:19:34,150 --> 00:19:33,120
been very disappointed with because

484
00:19:36,830 --> 00:19:34,160
somebody

485
00:19:39,669 --> 00:19:36,840
used practically no edge distance on

486
00:19:41,990 --> 00:19:39,679
stuff we want we won't mention any names

487
00:19:44,470 --> 00:19:42,000
but ron knows a guy that

488
00:19:46,630 --> 00:19:44,480

did this a few times on me

489
00:19:48,230 --> 00:19:46,640
but uh

490
00:19:51,029 --> 00:19:48,240
here is the

491
00:19:54,390 --> 00:19:51,039
edge distance and fastener spacing and

492
00:19:57,190 --> 00:19:54,400
these are nominal ones so so this is

493
00:19:59,990 --> 00:19:57,200
kind of what you shoot for 2d nominal

494
00:20:04,230 --> 00:20:00,000
where d is the diameter of the fastener

495
00:20:07,830 --> 00:20:04,240
4d spacing between fasteners

496
00:20:10,710 --> 00:20:07,840
and the aircraft companies usually use a

497
00:20:12,710 --> 00:20:10,720
2d plus 30 thousandths on their stuff

498
00:20:15,029 --> 00:20:12,720
just to give you just a little more edge

499
00:20:16,149 --> 00:20:15,039
distance in case you run into a problem

500
00:20:18,230 --> 00:20:16,159
now

501
00:20:21,190 --> 00:20:18,240
one of the things that questions might

502
00:20:23,110 --> 00:20:21,200
be asked well if you have a shearer lug

503
00:20:24,710 --> 00:20:23,120
it doesn't have 2d

504
00:20:26,710 --> 00:20:24,720
no they're custom designs because

505
00:20:28,789 --> 00:20:26,720
they're usually pretty thick and you go

506
00:20:31,110 --> 00:20:28,799
in and calculate

507
00:20:33,510 --> 00:20:31,120
hoop tension and shear tear out and that

508
00:20:34,789 --> 00:20:33,520
types of things on a lug

509
00:20:37,750 --> 00:20:34,799
and

510
00:20:40,310 --> 00:20:37,760
that one is covered

511
00:20:42,149 --> 00:20:40,320
uh i covered it in that

512
00:20:43,909 --> 00:20:42,159
the chapter i wrote for that textbook

513
00:20:45,990 --> 00:20:43,919

that's not out yet because that was on

514
00:20:49,029 --> 00:20:46,000
on fasteners and share

515
00:20:53,270 --> 00:20:49,039
and shigley and

516
00:20:57,110 --> 00:20:53,280
a few other people also have uh

517
00:20:58,549 --> 00:20:57,120
coverage on uh sheer and lug design

518
00:21:01,350 --> 00:20:58,559
when i talk about lug you're talking

519
00:21:04,070 --> 00:21:01,360
about a crank that is fairly a crank

520
00:21:06,230 --> 00:21:04,080
type thing that is fairly thick so and

521
00:21:07,190 --> 00:21:06,240
usually you have since it's a rotating

522
00:21:09,830 --> 00:21:07,200
type

523
00:21:12,390 --> 00:21:09,840
joint it does not

524
00:21:14,470 --> 00:21:12,400
have a large edge distance but it's got

525
00:21:16,870 --> 00:21:14,480
thick walls

526
00:21:19,110 --> 00:21:16,880
now here's here's something that i

527
00:21:20,549 --> 00:21:19,120
use to illustrate one of the other

528
00:21:24,310 --> 00:21:20,559
fallacies that we deal with in the

529
00:21:28,710 --> 00:21:25,110
the

530
00:21:30,710 --> 00:21:28,720
development of bearing stress allowables

531
00:21:33,270 --> 00:21:30,720
bearing stresses

532
00:21:34,310 --> 00:21:33,280
uh the the normal way of doing it you

533
00:21:36,789 --> 00:21:34,320
take

534
00:21:38,789 --> 00:21:36,799
this sheet is thickness t now this

535
00:21:40,310 --> 00:21:38,799
represents

536
00:21:42,310 --> 00:21:40,320
a uh

537
00:21:44,630 --> 00:21:42,320
semicircular there would be a fastener

538
00:21:46,870 --> 00:21:44,640

fitting in that hole and this represents

539
00:21:48,950 --> 00:21:46,880
the the lo the way we're

540
00:21:50,870 --> 00:21:48,960
coming up with the bearing stress here's

541
00:21:53,430 --> 00:21:50,880
what you're actually doing because if

542
00:21:54,870 --> 00:21:53,440
you have a fastener in this hole

543
00:21:57,510 --> 00:21:54,880
pushing

544
00:21:59,909 --> 00:21:57,520
the maximum stress is right here

545
00:22:01,270 --> 00:21:59,919
so this represents that maximum stress

546
00:22:03,350 --> 00:22:01,280
the here

547
00:22:05,590 --> 00:22:03,360
it's zero here because you're not

548
00:22:06,310 --> 00:22:05,600
putting any stress on it there

549
00:22:09,990 --> 00:22:06,320
so

550
00:22:11,270 --> 00:22:10,000
what we normally do and uh see uh mil

551
00:22:14,149 --> 00:22:11,280
standard

552
00:22:17,110 --> 00:22:14,159
1312 which we'll be covering later on in

553
00:22:18,630 --> 00:22:17,120
in here gives all the different methods

554
00:22:19,990 --> 00:22:18,640
of testing

555
00:22:22,870 --> 00:22:20,000
of fasteners

556
00:22:25,190 --> 00:22:22,880
well what they do they put the fastener

557
00:22:26,789 --> 00:22:25,200
in the material and they test it to

558
00:22:31,350 --> 00:22:26,799
failure

559
00:22:34,390 --> 00:22:31,360
failed at for a given diameter

560
00:22:36,070 --> 00:22:34,400
they divide it by the diameter times the

561
00:22:37,590 --> 00:22:36,080
thickness material that's your normal

562
00:22:40,230 --> 00:22:37,600
bearing area

563
00:22:42,630 --> 00:22:40,240

and say that's the bearing stress so if

564
00:22:46,149 --> 00:22:42,640
you look in mill handbook five or any of

565
00:22:48,789 --> 00:22:46,159
these books on bearing stress allowables

566
00:22:50,710 --> 00:22:48,799
you will see that they are way above

567
00:22:53,190 --> 00:22:50,720
tensile element and tensile yield

568
00:22:54,549 --> 00:22:53,200
because they're a fictitious thing

569
00:22:57,510 --> 00:22:54,559
what they are

570
00:23:00,630 --> 00:22:57,520
they're a value that has been verified

571
00:23:03,110 --> 00:23:00,640
that you can use it for calculations

572
00:23:05,750 --> 00:23:03,120
and get by with it but it's actually not

573
00:23:08,310 --> 00:23:05,760
a true stress

574
00:23:10,549 --> 00:23:08,320
so if you don't have bearing stress

575
00:23:12,070 --> 00:23:10,559
allowables for material

576
00:23:15,990 --> 00:23:12,080
since you see that these are

577
00:23:19,669 --> 00:23:16,000
proportional p1 to the compressive yield

578
00:23:23,750 --> 00:23:22,549
ultimate and so on you can come up with

579
00:23:27,029 --> 00:23:23,760
these

580
00:23:28,630 --> 00:23:27,039
just by taking one and a half times the

581
00:23:30,390 --> 00:23:28,640
compressive yield or compressive

582
00:23:33,350 --> 00:23:30,400
ultimate of the material

583
00:23:36,390 --> 00:23:33,360
now that is a conservative figure

584
00:23:39,430 --> 00:23:36,400
and because the actual test value will

585
00:23:41,190 --> 00:23:39,440
run around 1.7

586
00:23:44,149 --> 00:23:41,200
for most of these materials but mill

587
00:23:46,230 --> 00:23:44,159
handbook 5 if they didn't test

588
00:23:47,669 --> 00:23:46,240

to get the bearing allowables in a lot

589
00:23:49,750 --> 00:23:47,679
of cases they'll just take one and a

590
00:23:52,149 --> 00:23:49,760
half times the

591
00:23:53,510 --> 00:23:52,159
tensile element or tensile yield and

592
00:24:01,510 --> 00:23:53,520
slap that in there for the bearing

593
00:24:05,110 --> 00:24:03,190
all right grip length

594
00:24:07,350 --> 00:24:05,120
and shear head and tension head on

595
00:24:11,350 --> 00:24:07,360
fasteners now

596
00:24:13,990 --> 00:24:11,360
grip length is a very critical thing

597
00:24:17,190 --> 00:24:14,000
for shear design because that is the

598
00:24:18,390 --> 00:24:17,200
length of the unthreaded portion

599
00:24:20,470 --> 00:24:18,400
of the fastener

600
00:24:22,070 --> 00:24:20,480
and when you're you have it in shear and

601
00:24:24,870 --> 00:24:22,080
you try to keep

602
00:24:27,190 --> 00:24:24,880
have no threads in the hole

603
00:24:28,950 --> 00:24:27,200
so this is this is the thing that you

604
00:24:30,470 --> 00:24:28,960
you do here

605
00:24:33,269 --> 00:24:30,480
uh and

606
00:24:36,070 --> 00:24:33,279
you're supposed to size them the

607
00:24:38,390 --> 00:24:36,080
fastener such that this doesn't happen

608
00:24:40,230 --> 00:24:38,400
so you put a washer under the nut

609
00:24:42,149 --> 00:24:40,240
to allow tightening without running out

610
00:24:47,669 --> 00:24:42,159
of threads

611
00:24:49,350 --> 00:24:47,679
now the aerospace fasteners the ms nas

612
00:24:52,390 --> 00:24:49,360
am that type

613
00:24:54,870 --> 00:24:52,400

are available with sheer nuts or heads

614
00:24:57,990 --> 00:24:54,880
or tension

615
00:25:00,230 --> 00:24:58,000
heads and nuts to save weight on design

616
00:25:02,549 --> 00:25:00,240
because if you're designing in shear you

617
00:25:04,549 --> 00:25:02,559
don't need to have that much tension so

618
00:25:05,990 --> 00:25:04,559
therefore you can go with a thinner head

619
00:25:08,950 --> 00:25:06,000
or thinner nut

620
00:25:13,750 --> 00:25:08,960
so we have illustrations of those in the

621
00:25:18,390 --> 00:25:15,990
here is the grip length

622
00:25:21,190 --> 00:25:18,400
illustration it's the bottom of the head

623
00:25:22,549 --> 00:25:21,200
to the end of the threads

624
00:25:25,669 --> 00:25:22,559
and

625
00:25:27,269 --> 00:25:25,679
here is a shear head for a same size

626
00:25:29,190 --> 00:25:27,279
fastener it's an eighth of an inch thick

627
00:25:31,830 --> 00:25:29,200
down here it's uh

628
00:25:35,830 --> 00:25:31,840
5 30 seconds

629
00:25:39,990 --> 00:25:38,070
and notice two specs here that are

630
00:25:41,590 --> 00:25:40,000
called out

631
00:25:43,510 --> 00:25:41,600
which

632
00:25:45,590 --> 00:25:43,520
those of you that are familiar with the

633
00:25:49,110 --> 00:25:45,600
fasteners this is for j threads here the

634
00:25:51,029 --> 00:25:49,120
mill s 8879 and this is for the two

635
00:25:56,630 --> 00:25:51,039
two or class two or three and the

636
00:26:01,190 --> 00:25:58,549
here is a

637
00:26:04,149 --> 00:26:01,200
shear nut and a tension nut well you see

638
00:26:07,430 --> 00:26:04,159

the shear nut is pretty thin 203 versus

639
00:26:10,310 --> 00:26:07,440
284 for the tension nut so if you have a

640
00:26:12,470 --> 00:26:10,320
joint that is primarily shear you can

641
00:26:14,789 --> 00:26:12,480
put in a little nut like that and if

642
00:26:16,870 --> 00:26:14,799
you're using several hundred of them

643
00:26:24,710 --> 00:26:16,880
it saves you quite a bit in weight

644
00:26:30,390 --> 00:26:26,549
now here's here's another thing i keep

645
00:26:32,310 --> 00:26:30,400
coming back to avoid tapped holes

646
00:26:33,510 --> 00:26:32,320
uh we covered the tap tools and the type

647
00:26:35,909 --> 00:26:33,520
of taps

648
00:26:39,590 --> 00:26:35,919
and some here's some more reasons for

649
00:26:41,350 --> 00:26:39,600
avoiding tapped holes cost

650
00:26:42,789 --> 00:26:41,360
drilling and tapping a hole is expensive

651
00:26:45,190 --> 00:26:42,799
compared to drilling a clearance hole

652
00:26:46,789 --> 00:26:45,200
for a nut and bolt assembly

653
00:26:48,710 --> 00:26:46,799
inspection

654
00:26:53,269 --> 00:26:48,720
about the only thing you do

655
00:26:55,909 --> 00:26:53,279
with a tapped hole is a go no-go gauge

656
00:26:58,789 --> 00:26:55,919
and a minimum thread diameter check just

657
00:27:01,190 --> 00:26:58,799
by running a pin through it

658
00:27:02,630 --> 00:27:01,200
and the root radius you can't measure

659
00:27:04,789 --> 00:27:02,640
very well

660
00:27:07,110 --> 00:27:04,799
and since there's no such thing as a unj

661
00:27:09,190 --> 00:27:07,120
tap the root radius is not rounded if

662
00:27:11,029 --> 00:27:09,200
the hole's blind it'll have burrs

663
00:27:18,070 --> 00:27:11,039

shavings and everything else and you're

664
00:27:21,110 --> 00:27:19,269
now here's the

665
00:27:25,110 --> 00:27:21,120
the the other

666
00:27:26,149 --> 00:27:25,120
type of design that you need to look at

667
00:27:29,190 --> 00:27:26,159
is

668
00:27:30,470 --> 00:27:29,200
tension loads on a fastener group

669
00:27:32,310 --> 00:27:30,480
and uh

670
00:27:34,389 --> 00:27:32,320
at the time that i did this one i

671
00:27:36,870 --> 00:27:34,399
couldn't find one anywhere in anybody's

672
00:27:38,950 --> 00:27:36,880
book so i had to draw this one up myself

673
00:27:41,350 --> 00:27:38,960
but it didn't get too fatigued during

674
00:27:43,269 --> 00:27:41,360
our scanning so i guess it's all right

675
00:27:45,029 --> 00:27:43,279
and

676
00:27:47,750 --> 00:27:45,039
the

677
00:27:49,909 --> 00:27:47,760
here we have eight fasteners on a

678
00:27:52,710 --> 00:27:49,919
bracket that has two different loads on

679
00:27:54,789 --> 00:27:52,720
it it has a direct tension load p1 and

680
00:27:56,870 --> 00:27:54,799
it has a shear load p2 which also gives

681
00:27:57,990 --> 00:27:56,880
you a bending moment

682
00:28:00,710 --> 00:27:58,000
so

683
00:28:02,470 --> 00:28:00,720
what you're trying to do is get the

684
00:28:04,630 --> 00:28:02,480
total load

685
00:28:06,470 --> 00:28:04,640
on all of these fasteners

686
00:28:07,750 --> 00:28:06,480
using the different loads that we have

687
00:28:08,950 --> 00:28:07,760
there

688
00:28:10,630 --> 00:28:08,960

all right

689
00:28:19,510 --> 00:28:10,640
the

690
00:28:22,470 --> 00:28:19,520
where do you measure r from

691
00:28:24,950 --> 00:28:22,480
r is measured from the healing point

692
00:28:27,110 --> 00:28:24,960
for your sigma r squared

693
00:28:30,070 --> 00:28:27,120
because if this thing goes into

694
00:28:31,830 --> 00:28:30,080
compression over here

695
00:28:33,510 --> 00:28:31,840
then you're not getting anything out of

696
00:28:36,389 --> 00:28:33,520
it for your tension load so you can't

697
00:28:37,669 --> 00:28:36,399
use those two fasteners to carry the

698
00:28:38,950 --> 00:28:37,679
tension because they're in compression

699
00:28:40,310 --> 00:28:38,960
they're going to not going to help you

700
00:28:41,110 --> 00:28:40,320
any

701
00:28:43,190 --> 00:28:41,120
so

702
00:28:44,870 --> 00:28:43,200
what i did in this case

703
00:28:46,870 --> 00:28:44,880
since it's a bracket and this is a

704
00:28:48,950 --> 00:28:46,880
flange sticking out i said okay this

705
00:28:51,350 --> 00:28:48,960
thing is hard up to here so i'll measure

706
00:28:52,389 --> 00:28:51,360
my r's from that

707
00:28:54,149 --> 00:28:52,399
uh

708
00:28:56,630 --> 00:28:54,159
point to the right

709
00:28:58,470 --> 00:28:56,640
so i only have for my

710
00:29:01,029 --> 00:28:58,480
sigma r squared

711
00:29:03,590 --> 00:29:01,039
i only have six fasteners in it

712
00:29:05,909 --> 00:29:03,600
but then for the total shear

713
00:29:08,230 --> 00:29:05,919

i'm using all eight of them and for the

714
00:29:09,830 --> 00:29:08,240
total tension i'm using all eight of

715
00:29:13,269 --> 00:29:09,840
them

716
00:29:16,230 --> 00:29:13,279
so in doing that you can

717
00:29:17,990 --> 00:29:16,240
calculate the sigma r squared you divide

718
00:29:20,070 --> 00:29:18,000
the uh

719
00:29:21,669 --> 00:29:20,080
the load i better leave this up here

720
00:29:22,549 --> 00:29:21,679
from from my standpoint here for a

721
00:29:24,549 --> 00:29:22,559
moment

722
00:29:27,430 --> 00:29:24,559
you can divide the load by eight to get

723
00:29:28,710 --> 00:29:27,440
the one the shear loads then you can

724
00:29:29,990 --> 00:29:28,720
calculate

725
00:29:48,389 --> 00:29:30,000
the

726
00:29:50,630 --> 00:29:48,399
additional tension load

727
00:29:51,909 --> 00:29:50,640
and you can go in then and

728
00:29:55,269 --> 00:29:51,919
calculate

729
00:29:57,430 --> 00:29:55,279
the total load in tension then you have

730
00:29:58,310 --> 00:29:57,440
the shear load which was the p2 over

731
00:30:01,510 --> 00:29:58,320
eight

732
00:30:05,029 --> 00:30:01,520
and you can take those two loads now

733
00:30:07,269 --> 00:30:05,039
and go in and use stress ratios

734
00:30:10,310 --> 00:30:07,279
and calculate the margin of safety on

735
00:30:12,789 --> 00:30:10,320
the fastener for the total loading

736
00:30:15,750 --> 00:30:12,799
see here was the a better better print

737
00:30:18,789 --> 00:30:15,760
showing the the one for

738
00:30:20,310 --> 00:30:18,799

the uh p sub m value where you're

739
00:30:23,029 --> 00:30:20,320
actually getting the moment was the p2

740
00:30:27,590 --> 00:30:23,039
times h and that times r7 over the sigma

741
00:30:32,230 --> 00:30:30,149
now the tensile load that your preload

742
00:30:34,549 --> 00:30:32,240
that you're putting on these fasteners

743
00:30:37,110 --> 00:30:34,559
has to exceed p or you're in trouble

744
00:30:39,590 --> 00:30:37,120
because you don't want any joint

745
00:30:42,389 --> 00:30:39,600
loosening

746
00:30:44,230 --> 00:30:42,399
combined shear and tension loading

747
00:30:45,510 --> 00:30:44,240
now on this

748
00:30:47,830 --> 00:30:45,520
you have

749
00:30:49,430 --> 00:30:47,840
you get all your summation of loads in

750
00:30:51,510 --> 00:30:49,440
the shear direction you get all your

751
00:30:53,029 --> 00:30:51,520
summation of loads in the tension

752
00:30:54,870 --> 00:30:53,039
direction

753
00:30:57,509 --> 00:30:54,880
and then

754
00:31:00,230 --> 00:30:57,519
you could use a mortar circle

755
00:31:02,149 --> 00:31:00,240
and work with it and get the

756
00:31:03,509 --> 00:31:02,159
principal stresses and that type of

757
00:31:05,350 --> 00:31:03,519
thing and

758
00:31:07,909 --> 00:31:05,360
calculate out

759
00:31:09,590 --> 00:31:07,919
a and allowable and a margin of safety

760
00:31:11,590 --> 00:31:09,600
that way but it's easier to use these

761
00:31:12,789 --> 00:31:11,600
stress ratios because that's doing the

762
00:31:15,110 --> 00:31:12,799
same thing

763
00:31:17,509 --> 00:31:15,120

so what you do is you get two factors

764
00:31:20,230 --> 00:31:17,519
you get a

765
00:31:22,470 --> 00:31:20,240
r sub s or r sub t here which is the

766
00:31:24,310 --> 00:31:22,480
actual shear load over the allowable

767
00:31:25,190 --> 00:31:24,320
shear load for that fastener now in this

768
00:31:27,430 --> 00:31:25,200
case

769
00:31:29,590 --> 00:31:27,440
you can work in pounds you can work in

770
00:31:32,389 --> 00:31:29,600
uh stress either when you want to as

771
00:31:34,310 --> 00:31:32,399
long as you're consistent in your units

772
00:31:37,029 --> 00:31:34,320
so you get a

773
00:31:38,549 --> 00:31:37,039
a factor there you get one from tension

774
00:31:39,830 --> 00:31:38,559
the actual tension load over the

775
00:31:41,269 --> 00:31:39,840
allowable

776
00:31:44,230 --> 00:31:41,279
and then you get

777
00:31:47,430 --> 00:31:44,240
a margin of safety

778
00:31:50,389 --> 00:31:47,440
which takes the actual load

779
00:31:51,350 --> 00:31:50,399
over the one you calculated here minus

780
00:31:53,669 --> 00:31:51,360
one

781
00:31:56,630 --> 00:31:53,679
give a margin of safety now what happens

782
00:31:58,549 --> 00:31:56,640
with these these values when you combine

783
00:31:59,669 --> 00:31:58,559
them

784
00:32:00,549 --> 00:31:59,679
you get

785
00:32:02,230 --> 00:32:00,559
two

786
00:32:04,310 --> 00:32:02,240
values

787
00:32:05,750 --> 00:32:04,320
that have better be less than one for

788
00:32:07,029 --> 00:32:05,760

each one of them

789
00:32:08,549 --> 00:32:07,039
because you don't want either one of

790
00:32:11,350 --> 00:32:08,559
them be greater than one or you're in

791
00:32:12,470 --> 00:32:11,360
trouble on the design

792
00:32:15,190 --> 00:32:12,480
so

793
00:32:16,549 --> 00:32:15,200
you have these and they have exponents x

794
00:32:18,630 --> 00:32:16,559
and y

795
00:32:21,430 --> 00:32:18,640
now it depends on your degree of

796
00:32:23,509 --> 00:32:21,440
conservatism as to how how big an

797
00:32:25,430 --> 00:32:23,519
exponent you use for those because of

798
00:32:27,590 --> 00:32:25,440
course the

799
00:32:29,750 --> 00:32:27,600
the bigger the exponent goes the more

800
00:32:32,149 --> 00:32:29,760
unconservative you become

801
00:32:33,509 --> 00:32:32,159
because the sum of those two have to be

802
00:32:34,950 --> 00:32:33,519
less than one in order to have a

803
00:32:38,310 --> 00:32:34,960
positive margin

804
00:32:41,110 --> 00:32:38,320
because margin of safety

805
00:32:43,509 --> 00:32:41,120
and safety as a safety factor of one if

806
00:32:45,509 --> 00:32:43,519
you will so a margin safety of zero is a

807
00:32:47,669 --> 00:32:45,519
safety factor of one

808
00:32:49,430 --> 00:32:47,679
so therefore if uh

809
00:32:50,950 --> 00:32:49,440
people say oh well gee i got a margin of

810
00:32:53,190 --> 00:32:50,960
safety of

811
00:32:57,430 --> 00:32:53,200
0.03 on that part well that's still good

812
00:32:59,029 --> 00:32:57,440
because that's 1.03 safety factor-wise

813
00:33:01,430 --> 00:32:59,039

and that's the way the aerospace

814
00:33:03,909 --> 00:33:01,440
industry has been doing it

815
00:33:06,149 --> 00:33:03,919
ever since glenn l martin

816
00:33:07,269 --> 00:33:06,159
so here are these curves that you can

817
00:33:09,350 --> 00:33:07,279
use

818
00:33:11,350 --> 00:33:09,360
and it depends on how conservative or

819
00:33:13,110 --> 00:33:11,360
unconservative you want to be now for if

820
00:33:14,389 --> 00:33:13,120
you're the belt and suspenders type and

821
00:33:16,630 --> 00:33:14,399
want to make sure everything's all right

822
00:33:17,669 --> 00:33:16,640
you use a straight line version here

823
00:33:18,630 --> 00:33:17,679
which is

824
00:33:21,430 --> 00:33:18,640
uh

825
00:33:23,110 --> 00:33:21,440
just uses no exponents at all

826
00:33:25,509 --> 00:33:23,120
and calculate the margin and that one is

827
00:33:27,590 --> 00:33:25,519
a lot safer if you want to get

828
00:33:30,870 --> 00:33:27,600
more unsafe you can go further out on

829
00:33:33,590 --> 00:33:30,880
these by squaring and cubing these

830
00:33:34,549 --> 00:33:33,600
ratios and that will give you

831
00:33:39,430 --> 00:33:34,559
a

832
00:33:43,350 --> 00:33:41,269
now here's one

833
00:33:47,029 --> 00:33:43,360
that is uh another one that has always

834
00:33:48,950 --> 00:33:47,039
bothered me because in school

835
00:33:50,870 --> 00:33:48,960
i never did

836
00:33:53,750 --> 00:33:50,880
like the way these professors went

837
00:33:56,230 --> 00:33:53,760
through horizontal shear stress

838
00:33:59,669 --> 00:33:56,240

and said then the determination of this

839
00:34:00,470 --> 00:33:59,679
is an exercise left up to the student

840
00:34:04,789 --> 00:34:00,480
so

841
00:34:07,830 --> 00:34:04,799
this

842
00:34:09,270 --> 00:34:07,840
for uh the uh lecture that i give on

843
00:34:10,790 --> 00:34:09,280
fasteners

844
00:34:12,550 --> 00:34:10,800
and shear

845
00:34:14,710 --> 00:34:12,560
because it always bothered me that

846
00:34:15,750 --> 00:34:14,720
nobody had explained it very well and of

847
00:34:17,669 --> 00:34:15,760
course when you're looking for

848
00:34:19,510 --> 00:34:17,679
explanations and strength materials you

849
00:34:22,149 --> 00:34:19,520
go back to the basics

850
00:34:24,470 --> 00:34:22,159
back to the real source timoshenko

851
00:34:25,349 --> 00:34:24,480
so i found this in an old temeschenko

852
00:34:27,510 --> 00:34:25,359
book

853
00:34:29,589 --> 00:34:27,520
uh in which he explained it

854
00:34:31,270 --> 00:34:29,599
and it was the book was old enough that

855
00:34:32,829 --> 00:34:31,280
he wasn't working with bolts he was

856
00:34:34,869 --> 00:34:32,839
working with nails and

857
00:34:36,629 --> 00:34:34,879
tubaphores but nevertheless the

858
00:34:38,710 --> 00:34:36,639
principle was the same

859
00:34:40,629 --> 00:34:38,720
because when you have two pieces that

860
00:34:42,550 --> 00:34:40,639
you want to fasten together so that they

861
00:34:44,710 --> 00:34:42,560
act as a beam

862
00:34:49,109 --> 00:34:44,720
you have to have enough fasteners to

863
00:34:53,030 --> 00:34:51,270

for that to happen so this is a method

864
00:34:56,310 --> 00:34:53,040
of calculating it

865
00:34:58,150 --> 00:34:56,320
and this is the the vq over ib

866
00:34:59,430 --> 00:34:58,160
shear stress

867
00:35:00,550 --> 00:34:59,440
and

868
00:35:02,870 --> 00:35:00,560
so i

869
00:35:04,390 --> 00:35:02,880
set up a little problem

870
00:35:06,230 --> 00:35:04,400
and work through it here and these are

871
00:35:07,910 --> 00:35:06,240
the dimensions which i think most of

872
00:35:11,670 --> 00:35:07,920
them are given on the

873
00:35:11,680 --> 00:35:14,630
yeah

874
00:35:18,790 --> 00:35:16,710
now

875
00:35:21,349 --> 00:35:18,800
this is a uh

876
00:35:23,190 --> 00:35:21,359
the type of beam and i i just came came

877
00:35:25,910 --> 00:35:23,200
up with a kind of an artificial type

878
00:35:29,109 --> 00:35:25,920
thing to illustrate the point you have a

879
00:35:31,430 --> 00:35:29,119
400 pounds per inch loading

880
00:35:34,310 --> 00:35:31,440
and it's 50 inches long

881
00:35:36,230 --> 00:35:34,320
and it's made up of two one-inch plates

882
00:35:38,870 --> 00:35:36,240
and you're wanting to hold them together

883
00:35:40,630 --> 00:35:38,880
with bolts and you're going to have uh

884
00:35:42,710 --> 00:35:40,640
two two at a

885
00:35:46,230 --> 00:35:42,720
at each spot so you want to know how far

886
00:35:48,230 --> 00:35:46,240
apart your rose bolts need to be

887
00:35:50,550 --> 00:35:48,240
how far can you go and still hold the

888
00:35:52,230 --> 00:35:50,560

thing together

889
00:35:55,430 --> 00:35:52,240
so

890
00:35:56,870 --> 00:35:55,440
that's this e is the spacing here

891
00:35:58,790 --> 00:35:56,880
because you see what you actually get

892
00:36:00,230 --> 00:35:58,800
when you apply the moment

893
00:36:01,910 --> 00:36:00,240
then you have the horizontal shear

894
00:36:03,910 --> 00:36:01,920
surface here which in this case is the

895
00:36:06,870 --> 00:36:03,920
neutral axis of the beam

896
00:36:08,790 --> 00:36:06,880
and you need to calculate that stress

897
00:36:10,390 --> 00:36:08,800
and determine the bolts

898
00:36:12,630 --> 00:36:10,400
all right

899
00:36:14,710 --> 00:36:12,640
you get the reactions

900
00:36:17,349 --> 00:36:14,720
to the beam

901
00:36:19,510 --> 00:36:17,359
and then you get the moment

902
00:36:21,349 --> 00:36:19,520
it's a uniformly loaded beam so it's wl

903
00:36:23,190 --> 00:36:21,359
squared over eight

904
00:36:25,349 --> 00:36:23,200
and then

905
00:36:26,870 --> 00:36:25,359
you determine a value here because you

906
00:36:28,230 --> 00:36:26,880
also have to check bending stress to

907
00:36:30,150 --> 00:36:28,240
make sure that your bending stress is

908
00:36:32,069 --> 00:36:30,160
all right even if you do carry it carry

909
00:36:33,670 --> 00:36:32,079
the shear still has to hold it in

910
00:36:35,190 --> 00:36:33,680
bending

911
00:36:37,589 --> 00:36:35,200
so

912
00:36:39,270 --> 00:36:37,599
i just took a guess at the diameter bolt

913
00:36:40,790 --> 00:36:39,280

and said well i'll use a half inch bolt

914
00:36:42,470 --> 00:36:40,800
in this and see how it works out and

915
00:36:45,990 --> 00:36:42,480
then i'll calculate it

916
00:36:46,950 --> 00:36:46,000
so if you go into this the v q over ib

917
00:36:47,670 --> 00:36:46,960
remember

918
00:36:51,109 --> 00:36:47,680
the

919
00:36:54,390 --> 00:36:51,119
q

920
00:36:57,510 --> 00:36:54,400
is the what's called the statical moment

921
00:36:58,950 --> 00:36:57,520
which is the area above which you're

922
00:37:01,510 --> 00:36:58,960
wanting to

923
00:37:02,550 --> 00:37:01,520
check the stress above that shear plane

924
00:37:05,349 --> 00:37:02,560
times

925
00:37:07,829 --> 00:37:05,359
the distance to its centroid

926
00:37:11,670 --> 00:37:07,839
that's a statical moment

927
00:37:14,310 --> 00:37:11,680
then so so the q here was the

928
00:37:15,910 --> 00:37:14,320
i calculated was was three three inches

929
00:37:17,829 --> 00:37:15,920
uh cubed

930
00:37:20,150 --> 00:37:17,839
because it is a

931
00:37:21,589 --> 00:37:20,160
area times the distance so which makes

932
00:37:23,190 --> 00:37:21,599
it cubed

933
00:37:25,430 --> 00:37:23,200
then you go in and calculate the moment

934
00:37:27,510 --> 00:37:25,440
of inertia in this case i left out the

935
00:37:31,190 --> 00:37:27,520
diameter of the holes on this because i

936
00:37:35,430 --> 00:37:33,109
and of course one of the things you that

937
00:37:37,750 --> 00:37:35,440
you should do in the final calculations

938
00:37:39,589 --> 00:37:37,760

you actually deduct for the diameter of

939
00:37:42,069 --> 00:37:39,599
the holes in order to get the proper

940
00:37:44,550 --> 00:37:42,079
moment of inertia

941
00:37:46,710 --> 00:37:44,560
then i went in and said for no

942
00:37:48,829 --> 00:37:46,720
bolt hole reduction

943
00:37:51,589 --> 00:37:48,839
i'll have this

944
00:37:53,750 --> 00:37:51,599
stress now that'll be across that shaded

945
00:37:57,190 --> 00:37:53,760
area back in the figure there

946
00:37:58,710 --> 00:37:57,200
which was six wide so it was six e so i

947
00:37:59,589 --> 00:37:58,720
saw for

948
00:38:01,990 --> 00:37:59,599
the

949
00:38:04,470 --> 00:38:02,000
number of pounds that i would have that

950
00:38:07,109 --> 00:38:04,480
i'd have to react at that point all

951
00:38:08,870 --> 00:38:07,119
right if i take two half inch diameter

952
00:38:11,190 --> 00:38:08,880
grade five bolts good for about ten

953
00:38:12,950 --> 00:38:11,200
thousand five hundred pounds a piece and

954
00:38:15,670 --> 00:38:12,960
i'd divide

955
00:38:18,550 --> 00:38:15,680
this total load into that and solve for

956
00:38:21,109 --> 00:38:18,560
e i get 2.8 inches maximum spacing

957
00:38:22,230 --> 00:38:21,119
between row of bolts

958
00:38:24,870 --> 00:38:22,240
so

959
00:38:26,790 --> 00:38:24,880
then i went back and said okay i'll use

960
00:38:28,630 --> 00:38:26,800
9 16 bolts

961
00:38:31,270 --> 00:38:28,640
and with with a clearance hole and now

962
00:38:33,829 --> 00:38:31,280
i'll deduct for the

963
00:38:35,030 --> 00:38:33,839

holes that i'm taking out

964
00:38:36,710 --> 00:38:35,040
and

965
00:38:38,950 --> 00:38:36,720
calculate a new i

966
00:38:41,990 --> 00:38:38,960
and then go in and calculate the

967
00:38:45,270 --> 00:38:42,000
shearing stress take that to get me a

968
00:38:47,190 --> 00:38:45,280
value involving e and then solve for e

969
00:38:49,430 --> 00:38:47,200
using the higher allowables for the 9 16

970
00:38:52,710 --> 00:38:49,440
bolts and i get 2.94 inches for row

971
00:38:54,470 --> 00:38:52,720
spacing now you could optimize on that

972
00:38:57,109 --> 00:38:54,480
and do all sorts of things but what i

973
00:38:58,150 --> 00:38:57,119
was interested in here

974
00:39:00,550 --> 00:38:58,160
was just

975
00:39:03,589 --> 00:39:00,560
showing how you would do it

976
00:39:05,430 --> 00:39:03,599
because uh none of the books that i had

977
00:39:07,589 --> 00:39:05,440
actually strength material books showed

978
00:39:10,470 --> 00:39:07,599
that the way it was supposed to be i

979
00:39:14,150 --> 00:39:12,230
now you still have to go in and check

980
00:39:16,390 --> 00:39:14,160
for beam bending and bearing stress

981
00:39:17,349 --> 00:39:16,400
calculations

982
00:39:19,349 --> 00:39:17,359
and

983
00:39:21,349 --> 00:39:19,359
notice also that

984
00:39:23,910 --> 00:39:21,359
thin structures would have to be checked

985
00:39:24,870 --> 00:39:23,920
for inner rivet buckling because if you

986
00:39:26,550 --> 00:39:24,880
have

987
00:39:28,630 --> 00:39:26,560
thin sheet

988
00:39:31,510 --> 00:39:28,640

and your fasteners are spaced too far

989
00:39:34,069 --> 00:39:31,520
apart the sheet can buckle in between

990
00:39:35,750 --> 00:39:34,079
fasteners under compressive load

991
00:39:36,950 --> 00:39:35,760
and

992
00:39:38,310 --> 00:39:36,960
i

993
00:39:40,230 --> 00:39:38,320
you've heard that statement about a

994
00:39:41,190 --> 00:39:40,240
little knowledge is a dangerous thing i

995
00:39:43,030 --> 00:39:41,200
was

996
00:39:44,710 --> 00:39:43,040
telling a guy that this could happen one

997
00:39:47,510 --> 00:39:44,720
time at martin and he was taking

998
00:39:48,470 --> 00:39:47,520
strength materials so he said nah

999
00:39:51,829 --> 00:39:48,480
that

1000
00:39:54,150 --> 00:39:51,839
so i went to see one of the old-timers

1001
00:39:55,030 --> 00:39:54,160
to find out how to get out of it and he

1002
00:39:56,950 --> 00:39:55,040
said

1003
00:39:58,790 --> 00:39:56,960
well just go up and tear a page out of

1004
00:40:01,510 --> 00:39:58,800
his notebook that'll prove the point

1005
00:40:02,870 --> 00:40:01,520
because you see if you take a page

1006
00:40:04,710 --> 00:40:02,880
and you pull it

1007
00:40:07,589 --> 00:40:04,720
this way

1008
00:40:09,750 --> 00:40:07,599
the sheet will buckle between holes

1009
00:40:11,589 --> 00:40:09,760
before it tears up

1010
00:40:13,270 --> 00:40:11,599
so so i did that never had any more

1011
00:40:15,750 --> 00:40:13,280
trouble with the guy he went back to

1012
00:40:17,430 --> 00:40:15,760
strength materials book

1013
00:40:22,710 --> 00:40:17,440

so

1014
00:40:25,750 --> 00:40:22,720
horizontal shear loads now we go into

1015
00:40:28,870 --> 00:40:25,760
bolded flanges with o-rings now granted

1016
00:40:29,670 --> 00:40:28,880
that is a science within itself

1017
00:40:32,470 --> 00:40:29,680
but

1018
00:40:34,470 --> 00:40:32,480
we'll cover it here just to let you know

1019
00:40:37,109 --> 00:40:34,480
that you have to

1020
00:40:39,589 --> 00:40:37,119
do this with bolted joints

1021
00:40:41,349 --> 00:40:39,599
uh o-ring compression

1022
00:40:43,750 --> 00:40:41,359
in a flange is

1023
00:40:45,270 --> 00:40:43,760
usually just a small portion of the

1024
00:40:47,510 --> 00:40:45,280
total bolt load

1025
00:40:51,270 --> 00:40:47,520
and of course the o-ring groove is sized

1026
00:40:53,670 --> 00:40:51,280
to give a specific range of compression

1027
00:40:55,030 --> 00:40:53,680
on it when you go metal to metal on the

1028
00:40:57,589 --> 00:40:55,040
flanges

1029
00:40:58,870 --> 00:40:57,599
now for most o-rings this compression

1030
00:41:01,270 --> 00:40:58,880
value is like

1031
00:41:03,829 --> 00:41:01,280
a minimum of 10 to a maximum of about 30

1032
00:41:05,430 --> 00:41:03,839
percent of the unloaded cross-section

1033
00:41:07,510 --> 00:41:05,440
diameter

1034
00:41:10,550 --> 00:41:07,520
and of course the flange surfaces have

1035
00:41:12,710 --> 00:41:10,560
to be smooth to assure ceiling without

1036
00:41:14,870 --> 00:41:12,720
tearing up the o-ring

1037
00:41:16,230 --> 00:41:14,880
and the fastener spacing must be close

1038
00:41:17,670 --> 00:41:16,240

enough to keep the flanges from

1039
00:41:19,829 --> 00:41:17,680
separating that's one of the things you

1040
00:41:21,510 --> 00:41:19,839
have to watch about now granted in most

1041
00:41:22,470 --> 00:41:21,520
cases it's not a

1042
00:41:24,230 --> 00:41:22,480
problem

1043
00:41:26,710 --> 00:41:24,240
and of course the

1044
00:41:28,069 --> 00:41:26,720
this has uh just a general design

1045
00:41:29,829 --> 00:41:28,079
practice

1046
00:41:32,309 --> 00:41:29,839
you machine the o-ring groove in the

1047
00:41:34,710 --> 00:41:32,319
cheaper the two mating flanges

1048
00:41:36,230 --> 00:41:34,720
because if the machine is uh

1049
00:41:38,470 --> 00:41:36,240
if the machinist cuts the groove too

1050
00:41:39,910 --> 00:41:38,480
deep the parts scrap

1051
00:41:42,710 --> 00:41:39,920
so you want to make sure that it's in

1052
00:41:44,710 --> 00:41:42,720
the cheaper the two flanges and so you

1053
00:41:49,190 --> 00:41:44,720
can throw it away if you need to

1054
00:41:50,790 --> 00:41:49,200
and if you need a dovetail groove

1055
00:41:53,349 --> 00:41:50,800
to hold the o-ring in place during

1056
00:41:54,950 --> 00:41:53,359
assembly disassembly that also can be

1057
00:41:56,470 --> 00:41:54,960
machined in

1058
00:41:58,069 --> 00:41:56,480
now here is

1059
00:42:01,109 --> 00:41:58,079
a generic

1060
00:42:05,430 --> 00:42:02,390
and uh

1061
00:42:10,710 --> 00:42:08,550
there's the the o-ring normally the

1062
00:42:12,470 --> 00:42:10,720
the only thing you got to worry about is

1063
00:42:14,790 --> 00:42:12,480

having a smooth enough finish on this

1064
00:42:17,109 --> 00:42:14,800
mating surface in that area that it

1065
00:42:19,109 --> 00:42:17,119
doesn't chew up the o-ring

1066
00:42:23,030 --> 00:42:19,119
and have enough fasteners to keep the

1067
00:42:27,510 --> 00:42:25,030
now if you go to bolted flanges with

1068
00:42:30,710 --> 00:42:27,520
flat gaskets

1069
00:42:33,750 --> 00:42:30,720
then you got a another problem

1070
00:42:34,390 --> 00:42:33,760
you need to squeeze the gasket to seal

1071
00:42:36,630 --> 00:42:34,400
it

1072
00:42:38,870 --> 00:42:36,640
but on the other hand you don't want to

1073
00:42:41,670 --> 00:42:38,880
squeeze it so much

1074
00:42:43,430 --> 00:42:41,680
that you uh yield it in compression and

1075
00:42:46,790 --> 00:42:43,440
ruin it

1076
00:42:48,230 --> 00:42:46,800
so so now you have to look harder at the

1077
00:42:49,589 --> 00:42:48,240
amount of load that you're putting in

1078
00:42:51,990 --> 00:42:49,599
with your bolts

1079
00:42:54,069 --> 00:42:52,000
now a lot of gasket manufacturers would

1080
00:42:56,230 --> 00:42:54,079
give you a

1081
00:42:58,630 --> 00:42:56,240
pounds per linear inch or something for

1082
00:43:00,870 --> 00:42:58,640
a flat gasket so that you know them by

1083
00:43:03,829 --> 00:43:00,880
your bolt spacing how much you need to

1084
00:43:05,670 --> 00:43:03,839
put in to get the thing to seal

1085
00:43:07,829 --> 00:43:05,680
at least that gives you a minimum load

1086
00:43:09,589 --> 00:43:07,839
that you have to have and then then of

1087
00:43:12,069 --> 00:43:09,599
course you have to look at the

1088
00:43:13,990 --> 00:43:12,079

compressive yield of the gasket to see

1089
00:43:15,270 --> 00:43:14,000
whether you're putting too much load in

1090
00:43:16,069 --> 00:43:15,280
or not

1091
00:43:17,990 --> 00:43:16,079
so

1092
00:43:19,190 --> 00:43:18,000
usually the best thing to do on that is

1093
00:43:20,950 --> 00:43:19,200
is get the information from the

1094
00:43:23,030 --> 00:43:20,960
manufacturers because they they know

1095
00:43:25,190 --> 00:43:23,040
their their product well enough to give

1096
00:43:27,750 --> 00:43:25,200
you the

1097
00:43:29,270 --> 00:43:27,760
the proper values that you can use

1098
00:43:32,870 --> 00:43:29,280
and of course

1099
00:43:34,710 --> 00:43:32,880
we'll have some things in subsequent

1100
00:43:36,069 --> 00:43:34,720
sections on

1101
00:43:39,430 --> 00:43:36,079
what to do

1102
00:43:43,030 --> 00:43:39,440
where you have gaps on flanges now

1103
00:43:44,630 --> 00:43:43,040
here's a regular flat gasket

1104
00:43:45,589 --> 00:43:44,640
joint

1105
00:43:47,030 --> 00:43:45,599
and

1106
00:43:49,990 --> 00:43:47,040
one of the things you normally do with

1107
00:43:51,829 --> 00:43:50,000
gaskets too if you're in

1108
00:43:53,829 --> 00:43:51,839
the automotive world you use some sort

1109
00:43:55,510 --> 00:43:53,839
of a gasket cement sealer or something

1110
00:43:56,550 --> 00:43:55,520
of that nature on them

1111
00:43:58,390 --> 00:43:56,560
to

1112
00:44:03,270 --> 00:43:58,400
stick them in place

1113
00:44:07,430 --> 00:44:04,870

and we have

1114
00:44:09,910 --> 00:44:07,440
loading curves for the

1115
00:44:11,589 --> 00:44:09,920
flat gaskets in the appendix which you

1116
00:44:13,670 --> 00:44:11,599
get one of these days here in the near

1117
00:44:15,510 --> 00:44:13,680
future

1118
00:44:16,550 --> 00:44:15,520
and

1119
00:44:19,910 --> 00:44:16,560
the

1120
00:44:21,750 --> 00:44:19,920
flat gasket joint design

1121
00:44:23,349 --> 00:44:21,760
bickford has quite a bit more coverage

1122
00:44:24,230 --> 00:44:23,359
on it

1123
00:44:29,430 --> 00:44:24,240
and

1124
00:44:31,750 --> 00:44:29,440
chances are you can come up with enough

1125
00:44:36,230 --> 00:44:31,760
information for that

1126
00:44:38,069 --> 00:44:36,240
now gasket loads in flange joints

1127
00:44:41,030 --> 00:44:38,079
leaks usually start at the point of

1128
00:44:43,109 --> 00:44:41,040
maximum flange bending which is midway

1129
00:44:45,910 --> 00:44:43,119
between adjacent uh bolts where the

1130
00:44:48,230 --> 00:44:45,920
gasket's not compressed enough to seal

1131
00:44:50,550 --> 00:44:48,240
uh a lot of you have run into that in

1132
00:44:52,390 --> 00:44:50,560
the past with

1133
00:44:54,550 --> 00:44:52,400
valve covers on cars

1134
00:44:56,069 --> 00:44:54,560
they don't have enough

1135
00:44:58,550 --> 00:44:56,079
fasteners in them and you have cork

1136
00:44:59,990 --> 00:44:58,560
gaskets so you tighten them down and the

1137
00:45:02,470 --> 00:45:00,000
thing will bow

1138
00:45:08,710 --> 00:45:02,480

and leak in the middle and so you have

1139
00:45:13,430 --> 00:45:11,589
and so to increase the load at the

1140
00:45:15,109 --> 00:45:13,440
midway point you can look at three

1141
00:45:17,589 --> 00:45:15,119
different ways of doing it one is to

1142
00:45:20,150 --> 00:45:17,599
increase the number of bolts

1143
00:45:23,270 --> 00:45:20,160
increase the flange thickness

1144
00:45:24,950 --> 00:45:23,280
and increase the initial bolt torque

1145
00:45:26,550 --> 00:45:24,960
so those are three things that you can

1146
00:45:29,430 --> 00:45:26,560
look at all of which have their

1147
00:45:31,670 --> 00:45:29,440
advantages and disadvantages

1148
00:45:33,510 --> 00:45:31,680
the increased number of bolts

1149
00:45:36,230 --> 00:45:33,520
since deflection is proportional to the

1150
00:45:38,150 --> 00:45:36,240
cube of the span between bolt centers

1151
00:45:39,990 --> 00:45:38,160
that cuts way down on the deflection of

1152
00:45:42,069 --> 00:45:40,000
the flange

1153
00:45:46,230 --> 00:45:42,079
and so uh

1154
00:45:49,510 --> 00:45:46,240
so adding a bolted mid stand gives you

1155
00:45:52,870 --> 00:45:51,670
cut of 8 on the

1156
00:45:55,349 --> 00:45:52,880
deflection

1157
00:45:57,190 --> 00:45:55,359
and increases the gasket load the only

1158
00:45:59,349 --> 00:45:57,200
thing is

1159
00:46:01,190 --> 00:45:59,359
you increase the cost because you've now

1160
00:46:02,950 --> 00:46:01,200
added another bolt

1161
00:46:05,589 --> 00:46:02,960
another bull hole

1162
00:46:07,910 --> 00:46:05,599
increasing the flange thickness

1163
00:46:09,510 --> 00:46:07,920

now since flange deflection is inversely

1164
00:46:11,910 --> 00:46:09,520
proportional the cube to the flange

1165
00:46:13,510 --> 00:46:11,920
thickness you double the thickness it

1166
00:46:15,750 --> 00:46:13,520
decreases the flange deflection by a

1167
00:46:16,950 --> 00:46:15,760
factor of eight

1168
00:46:19,829 --> 00:46:16,960
so

1169
00:46:22,550 --> 00:46:19,839
that is a good thing except that

1170
00:46:24,630 --> 00:46:22,560
you increase the weight and the cost of

1171
00:46:29,670 --> 00:46:24,640
material so that's another thing that

1172
00:46:33,670 --> 00:46:32,309
now increasing the bolt torque

1173
00:46:36,470 --> 00:46:33,680
is

1174
00:46:39,349 --> 00:46:36,480
the cheapest way of doing it

1175
00:46:40,470 --> 00:46:39,359
but if you increase it to a certain

1176
00:46:42,630 --> 00:46:40,480
point

1177
00:46:43,750 --> 00:46:42,640
the flange can bend

1178
00:46:45,430 --> 00:46:43,760
in the middle

1179
00:46:47,270 --> 00:46:45,440
because you're compressing it down under

1180
00:46:49,109 --> 00:46:47,280
the bolt and allow it to bow up in the

1181
00:46:51,109 --> 00:46:49,119
middle where to leak worse so

1182
00:46:53,510 --> 00:46:51,119
particularly if you have a soft gasket

1183
00:46:55,030 --> 00:46:53,520
like the kirk gaskets

1184
00:46:56,950 --> 00:46:55,040
you you get leakage

1185
00:46:59,270 --> 00:46:56,960
so and if the bolt is near the yield

1186
00:47:00,870 --> 00:46:59,280
point a further increase in torque can't

1187
00:47:02,230 --> 00:47:00,880
be made unless you use bolts with a

1188
00:47:04,230 --> 00:47:02,240

higher strength

1189
00:47:06,230 --> 00:47:04,240
so one of the el cheapo ways that you

1190
00:47:09,190 --> 00:47:06,240
can do on this

1191
00:47:13,670 --> 00:47:12,069
extra diameter type uh washers under the

1192
00:47:15,589 --> 00:47:13,680
bolts to spread the load out just a

1193
00:47:17,510 --> 00:47:15,599
little bit sometimes that'll stop them

1194
00:47:21,750 --> 00:47:17,520
from leaking but that's not something

1195
00:47:26,069 --> 00:47:22,829
now getting

1196
00:47:27,829 --> 00:47:26,079
into bolted flanges for glass windows

1197
00:47:30,150 --> 00:47:27,839
the reason i put this in is this is a

1198
00:47:31,990 --> 00:47:30,160
special one and we've used it around

1199
00:47:34,630 --> 00:47:32,000
here on

1200
00:47:36,390 --> 00:47:34,640
designing of windows for

1201
00:47:38,870 --> 00:47:36,400
pressure vessels because normally you

1202
00:47:39,829 --> 00:47:38,880
don't think of a window as

1203
00:47:41,430 --> 00:47:39,839
needing

1204
00:47:43,349 --> 00:47:41,440
much in the way of gaskets and they more

1205
00:47:44,710 --> 00:47:43,359
or less just slap them in

1206
00:47:46,710 --> 00:47:44,720
and they're done with it they're in

1207
00:47:50,150 --> 00:47:46,720
cameras and things of this nature but

1208
00:47:52,950 --> 00:47:51,430
use

1209
00:47:56,150 --> 00:47:52,960
sight gauges

1210
00:47:58,470 --> 00:47:56,160
or in our case actually you in cm1 use

1211
00:48:02,390 --> 00:47:58,480
cameras through glass

1212
00:48:03,670 --> 00:48:02,400
now you wind up with an optical quality

1213
00:48:04,950 --> 00:48:03,680

window

1214
00:48:06,950 --> 00:48:04,960
that costs

1215
00:48:09,349 --> 00:48:06,960
several thousand dollars

1216
00:48:11,190 --> 00:48:09,359
that you need to make sure that nothing

1217
00:48:13,109 --> 00:48:11,200
happens to it

1218
00:48:15,589 --> 00:48:13,119
so the way to make sure nothing happens

1219
00:48:17,670 --> 00:48:15,599
to it is that you kind of pat it all the

1220
00:48:20,549 --> 00:48:17,680
way around with rubber

1221
00:48:22,230 --> 00:48:20,559
to keep it from touching the metal and

1222
00:48:24,390 --> 00:48:22,240
then of course the

1223
00:48:26,790 --> 00:48:24,400
one of the things about it in ours in

1224
00:48:29,670 --> 00:48:26,800
particular was that the

1225
00:48:31,589 --> 00:48:29,680
fastener design becomes a balancing act

1226
00:48:33,670 --> 00:48:31,599
to seal it without overloading it

1227
00:48:36,710 --> 00:48:33,680
because you don't want to overload it

1228
00:48:37,829 --> 00:48:36,720
and the other thing too is glass is so

1229
00:48:39,430 --> 00:48:37,839
brittle

1230
00:48:44,710 --> 00:48:39,440
the thing that causes it to fail of

1231
00:48:47,990 --> 00:48:46,230
you can't afford to scratch it with

1232
00:48:51,910 --> 00:48:48,000
anything

1233
00:48:55,750 --> 00:48:51,920
so uh it has a coefficient of thermal

1234
00:48:57,670 --> 00:48:55,760
expansion about 1 6 that of metal so if

1235
00:48:58,710 --> 00:48:57,680
you put it in and you have a temperature

1236
00:49:00,630 --> 00:48:58,720
change

1237
00:49:03,510 --> 00:49:00,640
now you have to put enough

1238
00:49:05,670 --> 00:49:03,520

padding around it of some sort

1239
00:49:08,549 --> 00:49:05,680
to allow it

1240
00:49:10,150 --> 00:49:08,559
to be compressed

1241
00:49:12,470 --> 00:49:10,160
uh by the

1242
00:49:14,549 --> 00:49:12,480
material around it or expanded and so on

1243
00:49:15,430 --> 00:49:14,559
without leaking so that's a balancing

1244
00:49:17,190 --> 00:49:15,440
act

1245
00:49:19,190 --> 00:49:17,200
so you sandwich it

1246
00:49:20,950 --> 00:49:19,200
in flat rubber gaskets with a bumper

1247
00:49:22,630 --> 00:49:20,960
strip around the outside of the window

1248
00:49:24,230 --> 00:49:22,640
to keep it from direct contact with the

1249
00:49:25,430 --> 00:49:24,240
metal

1250
00:49:27,190 --> 00:49:25,440
and

1251
00:49:30,630 --> 00:49:27,200
then

1252
00:49:32,069 --> 00:49:30,640
the balancing act is to seal it so that

1253
00:49:33,910 --> 00:49:32,079
it won't leak

1254
00:49:36,790 --> 00:49:33,920
but yet not

1255
00:49:38,950 --> 00:49:36,800
compress it too much

1256
00:49:40,549 --> 00:49:38,960
so we have a typical

1257
00:49:42,870 --> 00:49:40,559
design

1258
00:49:45,270 --> 00:49:42,880
shown in figure 35 which you can go and

1259
00:49:47,829 --> 00:49:45,280
put up there

1260
00:49:51,670 --> 00:49:49,030
now

1261
00:49:55,670 --> 00:49:51,680
this is a

1262
00:49:56,829 --> 00:49:55,680
model of what we actually used in cm1

1263
00:50:00,150 --> 00:49:56,839

except

1264
00:50:02,230 --> 00:50:00,160
that the one thing that i didn't show

1265
00:50:04,870 --> 00:50:02,240
just for clarity was the o-ring that we

1266
00:50:06,950 --> 00:50:04,880
had there but you see here i'll i'll use

1267
00:50:08,870 --> 00:50:06,960
this one it's a little clearer

1268
00:50:10,470 --> 00:50:08,880
here is the window

1269
00:50:12,150 --> 00:50:10,480
you have a bumper strip around the

1270
00:50:13,910 --> 00:50:12,160
outside now this is something that's not

1271
00:50:16,309 --> 00:50:13,920
a sealer it's just to keep it when you

1272
00:50:18,710 --> 00:50:16,319
drop it in the socket that it's in or

1273
00:50:20,870 --> 00:50:18,720
the well there to keep from touching it

1274
00:50:23,109 --> 00:50:20,880
you have rubber gaskets on the bottom

1275
00:50:25,750 --> 00:50:23,119
you have a round gasket there

1276
00:50:28,390 --> 00:50:25,760
and then you have one on top

1277
00:50:30,150 --> 00:50:28,400
now what what you're doing here

1278
00:50:31,990 --> 00:50:30,160
you're going metal to metal with this

1279
00:50:35,670 --> 00:50:32,000
top flange

1280
00:50:36,710 --> 00:50:35,680
now you have to use the tolerances of

1281
00:50:38,870 --> 00:50:36,720
both

1282
00:50:41,670 --> 00:50:38,880
on machining of this

1283
00:50:43,190 --> 00:50:41,680
and machining of this surface in order

1284
00:50:46,309 --> 00:50:43,200
to

1285
00:50:48,390 --> 00:50:46,319
make sure that you can put that a window

1286
00:50:51,190 --> 00:50:48,400
in there

1287
00:50:53,190 --> 00:50:51,200
size your gaskets properly in some cases

1288
00:50:55,430 --> 00:50:53,200

you have to grind them to get them to

1289
00:50:57,190 --> 00:50:55,440
the right diameter i mean right

1290
00:50:58,790 --> 00:50:57,200
thickness because the rubber is not

1291
00:51:01,750 --> 00:50:58,800
close enough tolerance

1292
00:51:03,190 --> 00:51:01,760
put it in there bolt it all down

1293
00:51:05,190 --> 00:51:03,200
and seal it

1294
00:51:07,270 --> 00:51:05,200
without hurting anything

1295
00:51:09,589 --> 00:51:07,280
so that is a special design within

1296
00:51:10,950 --> 00:51:09,599
itself and of course with your bolts you

1297
00:51:12,630 --> 00:51:10,960
have to make sure that they're strong

1298
00:51:14,710 --> 00:51:12,640
enough to

1299
00:51:19,270 --> 00:51:14,720
go metal to metal and load the thing up

1300
00:51:23,030 --> 00:51:21,349
now the effect of friction in a clamp

1301
00:51:24,870 --> 00:51:23,040
joint

1302
00:51:26,630 --> 00:51:24,880
in most cases

1303
00:51:27,670 --> 00:51:26,640
friction forces

1304
00:51:29,349 --> 00:51:27,680
between

1305
00:51:31,430 --> 00:51:29,359
clamp surfaces

1306
00:51:35,750 --> 00:51:31,440
are not included in the shear

1307
00:51:39,190 --> 00:51:37,670
the reason being

1308
00:51:40,549 --> 00:51:39,200
that's too hard to determine what they

1309
00:51:42,549 --> 00:51:40,559
are

1310
00:51:45,750 --> 00:51:42,559
because if you've got

1311
00:51:47,750 --> 00:51:45,760
oil or grease on the surfaces

1312
00:51:49,190 --> 00:51:47,760
the your friction coefficient could be

1313
00:51:52,069 --> 00:51:49,200

real low

1314
00:51:55,910 --> 00:51:53,990
striations of some kind on it it could

1315
00:51:57,430 --> 00:51:55,920
get real high but you really don't know

1316
00:51:59,750 --> 00:51:57,440
what it is

1317
00:52:01,190 --> 00:51:59,760
so for that reason you normally

1318
00:52:02,470 --> 00:52:01,200
don't include

1319
00:52:06,790 --> 00:52:02,480
the

1320
00:52:07,829 --> 00:52:06,800
coefficient of friction

1321
00:52:09,030 --> 00:52:07,839
as a

1322
00:52:11,670 --> 00:52:09,040
shear

1323
00:52:14,790 --> 00:52:11,680
capability that you have now there are a

1324
00:52:16,630 --> 00:52:14,800
few cases and the next page will show

1325
00:52:18,790 --> 00:52:16,640
there are the actual friction forces

1326
00:52:22,630 --> 00:52:18,800
that you can get

1327
00:52:24,710 --> 00:52:22,640
you see you have a bolt preload of p

1328
00:52:26,470 --> 00:52:24,720
and so you take that times the

1329
00:52:28,069 --> 00:52:26,480
coefficient of friction on this surface

1330
00:52:29,589 --> 00:52:28,079
and this surface and you got two forces

1331
00:52:30,390 --> 00:52:29,599
here

1332
00:52:31,670 --> 00:52:30,400
that

1333
00:52:33,829 --> 00:52:31,680
two

1334
00:52:35,990 --> 00:52:33,839
of these n forces and the n is the

1335
00:52:38,790 --> 00:52:36,000
friction load

1336
00:52:40,549 --> 00:52:38,800
uh which is the normal load

1337
00:52:41,670 --> 00:52:40,559
times the coefficient of friction by

1338
00:52:42,390 --> 00:52:41,680

definition

1339
00:52:46,390 --> 00:52:42,400
so

1340
00:52:47,589 --> 00:52:46,400
they actually

1341
00:52:49,349 --> 00:52:47,599
use

1342
00:52:51,589 --> 00:52:49,359
this friction

1343
00:52:52,870 --> 00:52:51,599
load

1344
00:52:55,510 --> 00:52:52,880
when they

1345
00:52:56,950 --> 00:52:55,520
are doing the joint calculations because

1346
00:52:58,790 --> 00:52:56,960
they count on it

1347
00:53:01,349 --> 00:52:58,800
but you it's not something that you

1348
00:53:03,829 --> 00:53:01,359
would normally count on because it's too

1349
00:53:05,190 --> 00:53:03,839
unpredictable

1350
00:53:06,870 --> 00:53:05,200
now the

1351
00:53:09,750 --> 00:53:06,880
compression

1352
00:53:13,030 --> 00:53:09,760
cone of a bolted joint

1353
00:53:15,190 --> 00:53:13,040
we covered this earlier there

1354
00:53:17,670 --> 00:53:15,200
in the stiffness section

1355
00:53:20,870 --> 00:53:17,680
but uh

1356
00:53:23,190 --> 00:53:20,880
in the appendices we do give more stuff

1357
00:53:25,109 --> 00:53:23,200
on it and the

1358
00:53:27,430 --> 00:53:25,119
here's something that i alluded to

1359
00:53:29,990 --> 00:53:27,440
earlier the bulk joint relative

1360
00:53:31,349 --> 00:53:30,000
stiffness calculations

1361
00:53:34,630 --> 00:53:31,359
and

1362
00:53:36,790 --> 00:53:34,640
most of the ordinary designs are not a

1363
00:53:40,390 --> 00:53:36,800

big requirement it's just that where you

1364
00:53:42,470 --> 00:53:40,400
have say small areas

1365
00:53:45,430 --> 00:53:42,480
that you would want to uh like for

1366
00:53:46,710 --> 00:53:45,440
instance if you had some now if uh one

1367
00:53:49,030 --> 00:53:46,720
of the things that would be a real

1368
00:53:50,790 --> 00:53:49,040
problem if you have a bushing type thing

1369
00:53:52,870 --> 00:53:50,800
around the bolt or a spacer or something

1370
00:53:54,710 --> 00:53:52,880
like that then then you better go in and

1371
00:53:57,190 --> 00:53:54,720
check happen real fast because you could

1372
00:53:58,549 --> 00:53:57,200
get into trouble but if you have

1373
00:53:59,670 --> 00:53:58,559
uh

1374
00:54:02,630 --> 00:53:59,680
say

1375
00:54:04,309 --> 00:54:02,640
uh steel and you're using steel bolts

1376
00:54:05,589 --> 00:54:04,319
chances are the joint is going to be

1377
00:54:08,309 --> 00:54:05,599
stiff enough that you don't have a

1378
00:54:10,549 --> 00:54:08,319
problem with it you can look at it

1379
00:54:13,990 --> 00:54:10,559
and take the the method at least work on

1380
00:54:16,309 --> 00:54:14,000
it calculate a circular

1381
00:54:19,109 --> 00:54:16,319
model for the stiffness if that is

1382
00:54:21,510 --> 00:54:19,119
satisfactory then go no further now if

1383
00:54:22,630 --> 00:54:21,520
if you were bowling say through

1384
00:54:25,990 --> 00:54:22,640
all

1385
00:54:28,790 --> 00:54:26,000
soft aluminum copper something like that

1386
00:54:30,710 --> 00:54:28,800
then you would probably want to do some

1387
00:54:33,349 --> 00:54:30,720
joint stiffness calculations to make

1388
00:54:36,390 --> 00:54:33,359

sure that you're not in trouble

1389
00:54:38,549 --> 00:54:36,400
but in in most cases you can get by with

1390
00:54:40,950 --> 00:54:38,559
a minimal amount of joint stiffness

1391
00:54:44,789 --> 00:54:40,960
calculations

1392
00:54:47,430 --> 00:54:44,799
now bolding of dissimilar materials

1393
00:54:48,789 --> 00:54:47,440
as i mentioned earlier in the centaur

1394
00:54:51,670 --> 00:54:48,799
case where you went from room

1395
00:54:53,270 --> 00:54:51,680
temperature to -300 or something like

1396
00:54:55,430 --> 00:54:53,280
that

1397
00:54:57,190 --> 00:54:55,440
with dissimilar materials there you got

1398
00:54:59,270 --> 00:54:57,200
a real problem because of the

1399
00:55:00,710 --> 00:54:59,280
differential thermal expansion and

1400
00:55:05,030 --> 00:55:00,720
contraction

1401
00:55:10,870 --> 00:55:07,270
let's see something like

1402
00:55:12,950 --> 00:55:10,880
three times i believe isn't it the uh

1403
00:55:15,349 --> 00:55:12,960
on thermal

1404
00:55:20,710 --> 00:55:15,359
something like three times as

1405
00:55:25,190 --> 00:55:23,430
and copper is way up there so if you're

1406
00:55:26,630 --> 00:55:25,200
if you're bolding up a copper joint you

1407
00:55:28,630 --> 00:55:26,640
have a temperature change you got to be

1408
00:55:30,309 --> 00:55:28,640
real careful on it

1409
00:55:32,470 --> 00:55:30,319
but uh

1410
00:55:34,150 --> 00:55:32,480
then the the other thing

1411
00:55:36,150 --> 00:55:34,160
that you needed watch for is the

1412
00:55:38,230 --> 00:55:36,160
galvanic corrosion

1413
00:55:39,990 --> 00:55:38,240

because unless the mating surfaces are

1414
00:55:42,230 --> 00:55:40,000
insulated from each other

1415
00:55:43,510 --> 00:55:42,240
and that was one of the reasons

1416
00:55:45,670 --> 00:55:43,520
why the

1417
00:55:47,589 --> 00:55:45,680
magnesium is kind of going out of vogue

1418
00:55:49,430 --> 00:55:47,599
because how do you

1419
00:55:51,670 --> 00:55:49,440
how do you

1420
00:55:53,510 --> 00:55:51,680
insulate it satisfactorily that over a

1421
00:55:55,430 --> 00:55:53,520
period of 20 years if it's used in the

1422
00:55:57,109 --> 00:55:55,440
airplane component that it's going to

1423
00:55:59,030 --> 00:55:57,119
stay insulated

1424
00:56:01,109 --> 00:55:59,040
because a lot of these

1425
00:56:02,710 --> 00:56:01,119
organic type things that they use for

1426
00:56:04,630 --> 00:56:02,720
insulation

1427
00:56:06,870 --> 00:56:04,640
the sealers that they put around rivets

1428
00:56:10,309 --> 00:56:06,880
bolts and stuff like that on airplanes

1429
00:56:13,030 --> 00:56:10,319
over a period of years can deteriorate

1430
00:56:14,950 --> 00:56:13,040
and moisture and the other the other

1431
00:56:18,470 --> 00:56:14,960
problem with the

1432
00:56:19,990 --> 00:56:18,480
the fasteners on an airplane is that

1433
00:56:21,589 --> 00:56:20,000
most of them

1434
00:56:24,069 --> 00:56:21,599
you're looking at heads

1435
00:56:26,630 --> 00:56:24,079
sticking out so if you have a crack that

1436
00:56:28,390 --> 00:56:26,640
is starting at the edge of the hole

1437
00:56:33,030 --> 00:56:28,400
it has to come out quite a ways before

1438
00:56:35,190 --> 00:56:33,040

you can see it so so that has caused

1439
00:56:37,109 --> 00:56:35,200
a lot of problems there

1440
00:56:39,190 --> 00:56:37,119
the other thing that you need to look at

1441
00:56:42,789 --> 00:56:39,200
is the yielding of softer materials

1442
00:56:45,349 --> 00:56:42,799
because if you are say using a

1443
00:56:47,109 --> 00:56:45,359
high-strength bolt in aluminum and you

1444
00:56:48,870 --> 00:56:47,119
crank that up too much you can actually

1445
00:56:50,150 --> 00:56:48,880
yield the aluminum in compression under

1446
00:56:52,950 --> 00:56:50,160
the head

1447
00:56:54,549 --> 00:56:52,960
without doing anything to the bolt

1448
00:56:56,069 --> 00:56:54,559
so uh

1449
00:56:57,670 --> 00:56:56,079
and then of course you've got to check

1450
00:57:00,150 --> 00:56:57,680
the strengths at the temperature

1451
00:57:01,670 --> 00:57:00,160
extremes because like for instance

1452
00:57:04,390 --> 00:57:01,680
aluminum

1453
00:57:08,390 --> 00:57:04,400
uh falls off drastically

1454
00:57:11,910 --> 00:57:08,400
at only 250 degrees whereas steel most

1455
00:57:14,549 --> 00:57:11,920
steels will go up to 700 and up before

1456
00:57:16,390 --> 00:57:14,559
they start falling off in strength so so

1457
00:57:18,549 --> 00:57:16,400
if you were

1458
00:57:21,750 --> 00:57:18,559
tightening up an aluminum joint and you

1459
00:57:23,910 --> 00:57:21,760
ran it up to say 250 300 degrees you

1460
00:57:28,630 --> 00:57:23,920
could get yielding real easy under the

1461
00:57:33,349 --> 00:57:31,510
now maximizing the effective length of

1462
00:57:35,430 --> 00:57:33,359
fasteners of course when we discussed

1463
00:57:37,510 --> 00:57:35,440

the stiffness ratios the effective

1464
00:57:38,870 --> 00:57:37,520
length of the fastener was mentioned

1465
00:57:41,510 --> 00:57:38,880
and this is important on the

1466
00:57:42,789 --> 00:57:41,520
differential expansion contraction

1467
00:57:46,390 --> 00:57:42,799
so

1468
00:57:48,470 --> 00:57:46,400
it may be necessary to add a spring

1469
00:57:50,549 --> 00:57:48,480
or a belleville washer under a bolt head

1470
00:57:52,390 --> 00:57:50,559
to increase its effective length enough

1471
00:57:55,430 --> 00:57:52,400
to satisfy the design so that it won't

1472
00:57:57,270 --> 00:57:55,440
loosen up and

1473
00:57:59,349 --> 00:57:57,280
the deflection of course is the pl over

1474
00:58:01,670 --> 00:57:59,359
e so you increase l you're

1475
00:58:03,349 --> 00:58:01,680
doing all right on it in fact on the

1476
00:58:04,549 --> 00:58:03,359
exhaust system

1477
00:58:06,390 --> 00:58:04,559
on uh

1478
00:58:10,710 --> 00:58:06,400
some of the ford trucks

1479
00:58:13,270 --> 00:58:10,720
they actually have a big spring

1480
00:58:15,030 --> 00:58:13,280
on the bolt that holds the flange to the

1481
00:58:17,829 --> 00:58:15,040
catalytic converter

1482
00:58:18,870 --> 00:58:17,839
it's put on there i think to take the

1483
00:58:20,390 --> 00:58:18,880
temperature

1484
00:58:21,510 --> 00:58:20,400
differential that you get between the

1485
00:58:23,670 --> 00:58:21,520
materials

1486
00:58:26,390 --> 00:58:23,680
on because you can go from room

1487
00:58:28,390 --> 00:58:26,400
temperature up to about

1488
00:58:32,789 --> 00:58:28,400

1300 degrees or something like that on

1489
00:58:38,710 --> 00:58:36,630
okay we'll take a break cure for now and

1490
00:58:41,030 --> 00:58:38,720
come back up with the match drilling of