
# Z FLANGE BOLTED CONNECTION

Foundation Ex Offshore Wind Conference, Bristol

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ENVIRONMENTAL

PIONEERS






**Specialised Expertise**: Offshore wind engineering consultancy designing the global energy transition.

**Global Presence**: >180 experts spanning UK, Denmark, Europe, USA and APAC.

**Cutting-Edge Tools**: Combining in-house expertise with proprietary engineering software for optimised results.

**A Trusted Partner**: Repeatedly partner with some of the biggest names in the energy industry.

**Sustainability Leadership**: Balancing the needs of clients, people and the planet.

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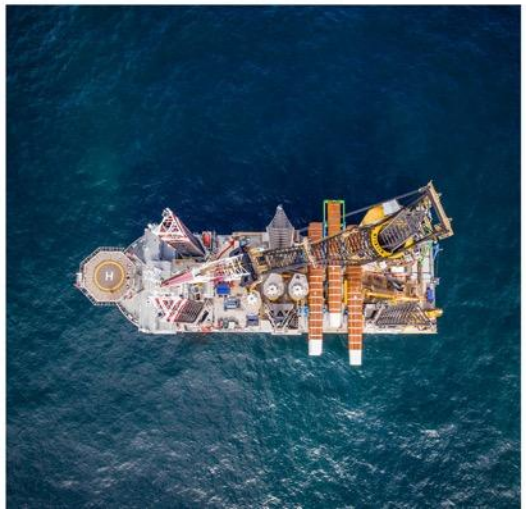
WT



DESIGNING THE

GLOBAL ENERGY

TRANSITION





# A WORLD OF EXPERIENCE


## Local Expertise, Global Support

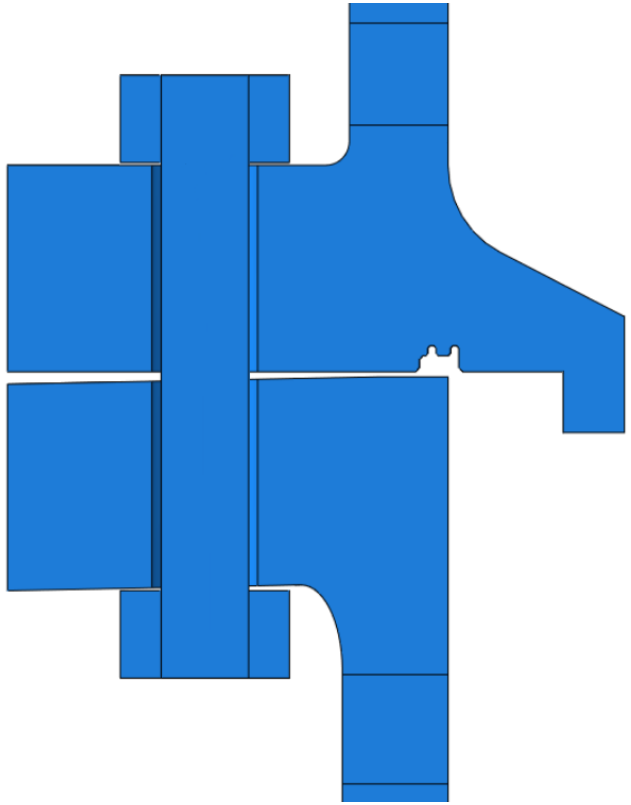
Our regional teams are strategically positioned to deliver in-country expertise and local client support, backed by a global network of world-class engineers.

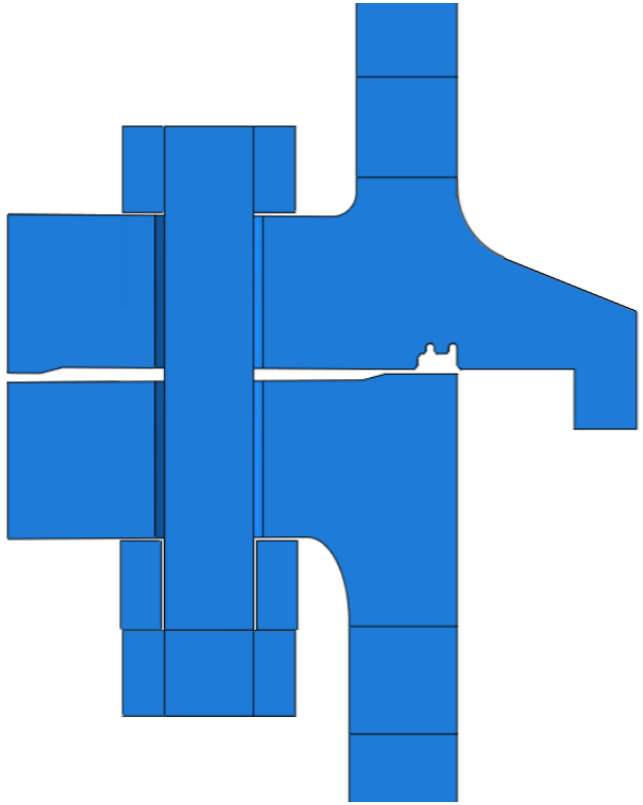
# LOTS OF QUESTIONS!

- What is the Z flange?
- What problem is it trying to solve?
- How does it work?
- How does it perform through life?
- How is it designed / analysed?
- How is it fabricated?
- How is it better than an L-flange or any of the alternatives?
- Where has it been used?
- What level of development is it at? (patents, etc.)
- Any effect from recent code changes around flatness tolerances?
- Where should we use it?

WOOD THILSTED

# WHAT IS THE Z FLANGE?





| Tapered L flange | Z flange |
| --- | --- |
| ▸ Tapered towards ID for impact driving | ▸ Step provides clearance for impact driving |
| ▸ Contact across tapered part of flange face | ▸ Contact at OD and ID only |
| ▸ Maximise flange thickness for design | ▸ 30 – 60% thinner than tapered flange |

# WHAT PROBLEM IS IT TRYING TO SOLVE?

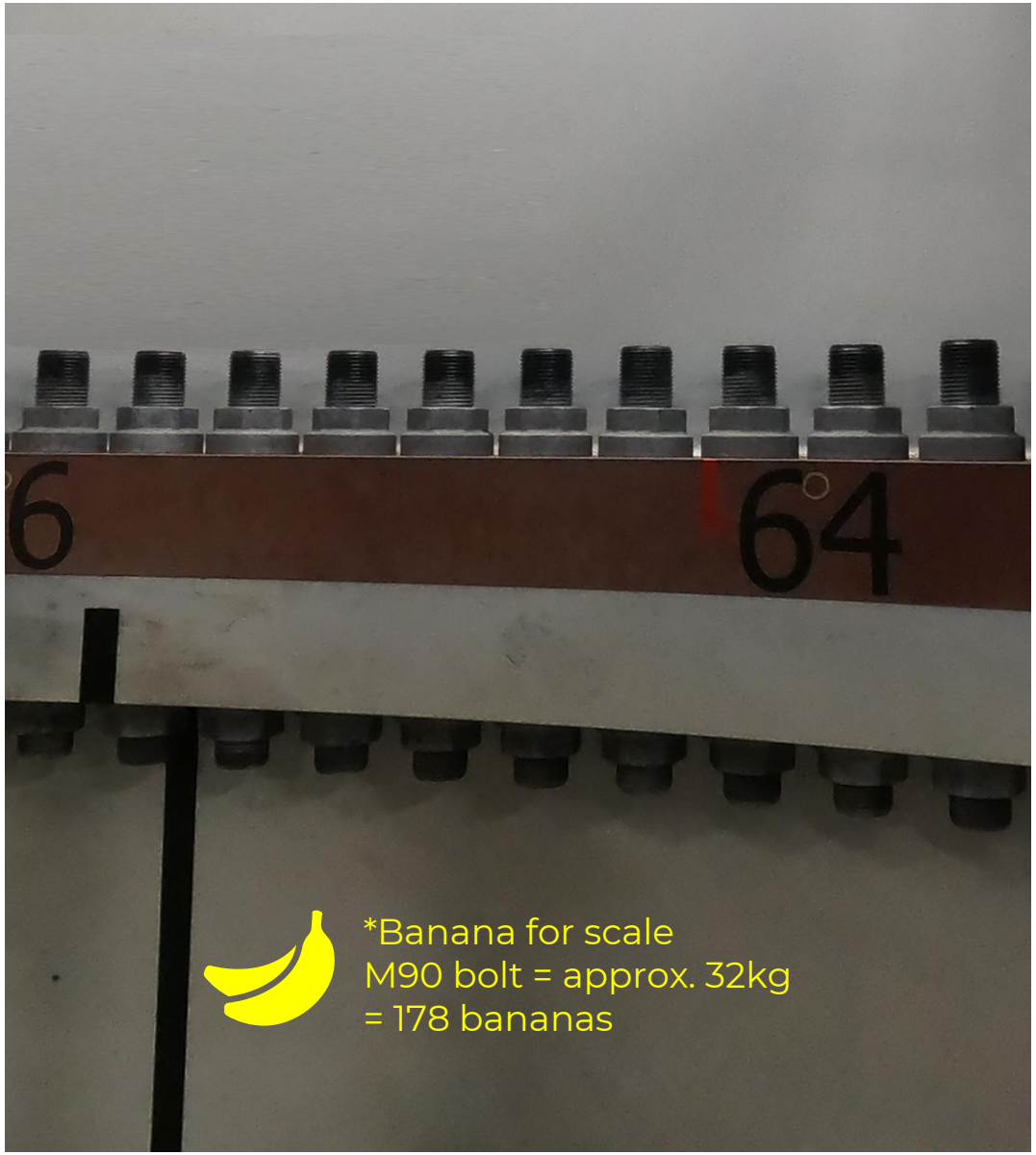
## As turbines get bigger…

Challenges for bolted flange connections:

- Increasingly difficult to validate traditional L flange connections within typical design code, fabrication and installation constraints
- Flatness tolerance limits
- Preload requirements
- Relaxation of acceptance criteria becoming required.

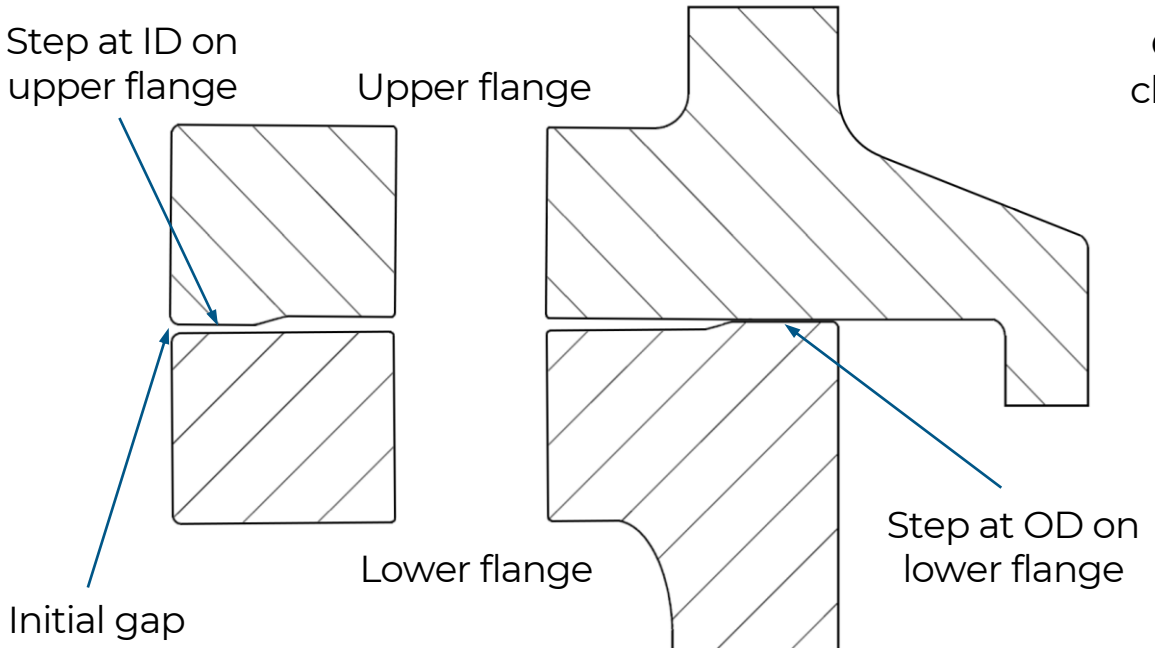
Reasons to use a bolted flange connection:

- Long-term industry experience
- Reduced steel mass *vs.* grouted or friction joint connections
- Reduced fabrication and installation complexity vs. alternative design connections
- High maintainability vs. grouted or friction joint connections.

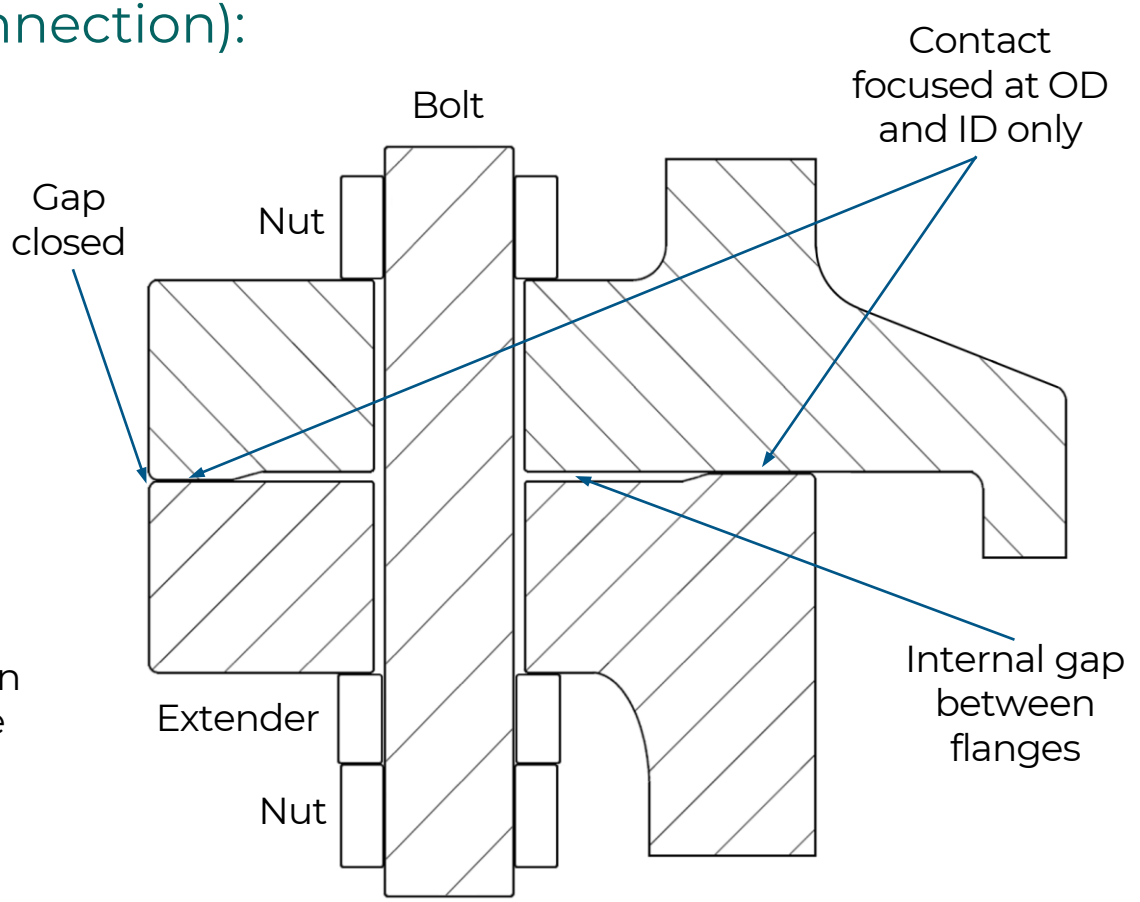


# HOW DOES IT WORK?

## Z flange general configuration (MP-TP connection):




**Set-down, unbolted**

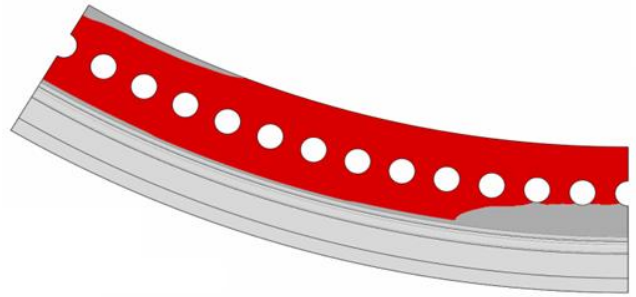


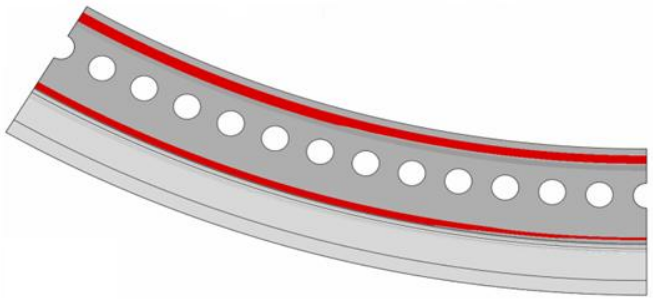

**Bolted**

# HOW DOES IT WORK?

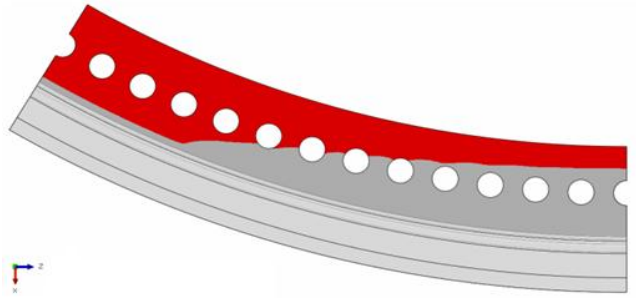
## Comparison between tapered flange and Z flange

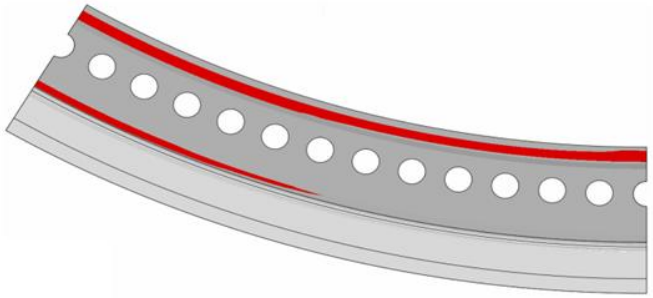
**Bolts preloaded, zero external load:**





**External load:**



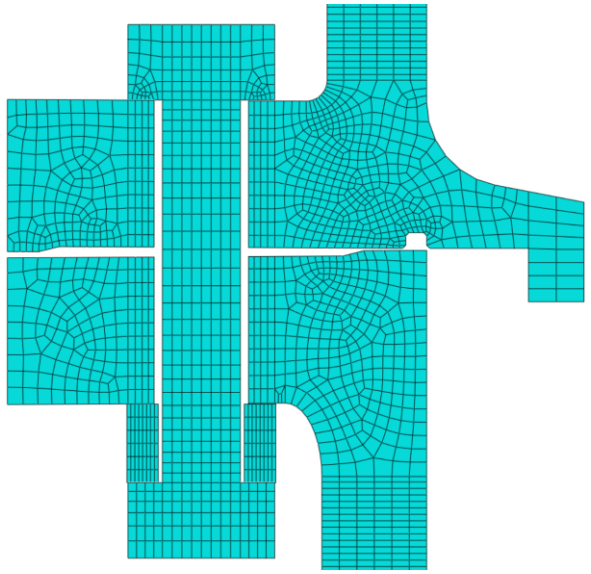


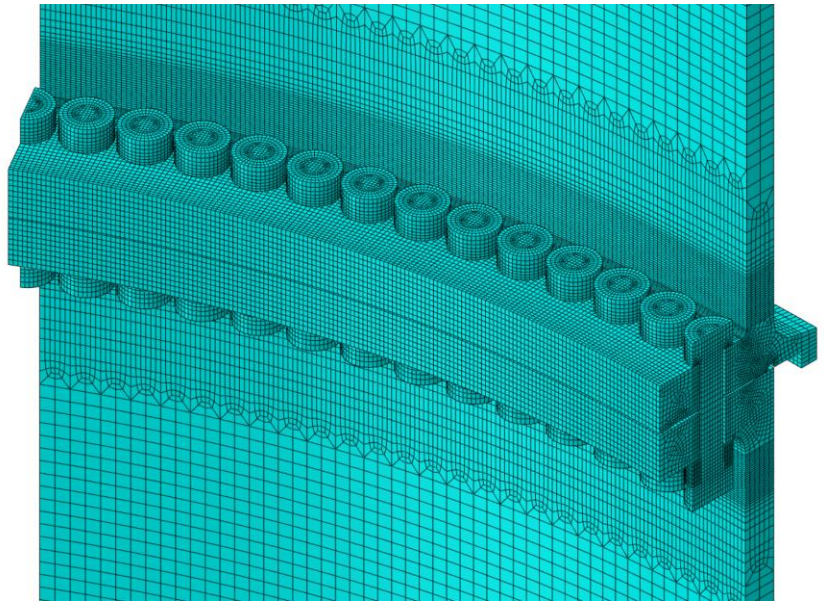
| Tapered flange | Z flange |
|---|---|
| ▸ Typical minor gap at OD due to waviness | ▸ Gap strip at OD fully closed |
| ▸ External load leads to prying and gapping | ▸ Slower initial prying at OD |

# HOW IS IT DESIGNED/ANALYSED?

1. Define major flange geometry
   - Limiting envelope: OD, shell thickness, flange width, height
   - BCD, number of bolts
   - Step width OD and ID
2. Find flange thickness
3. Find limiting fabrication tolerances
4. Repeat for smaller bolt size if possible

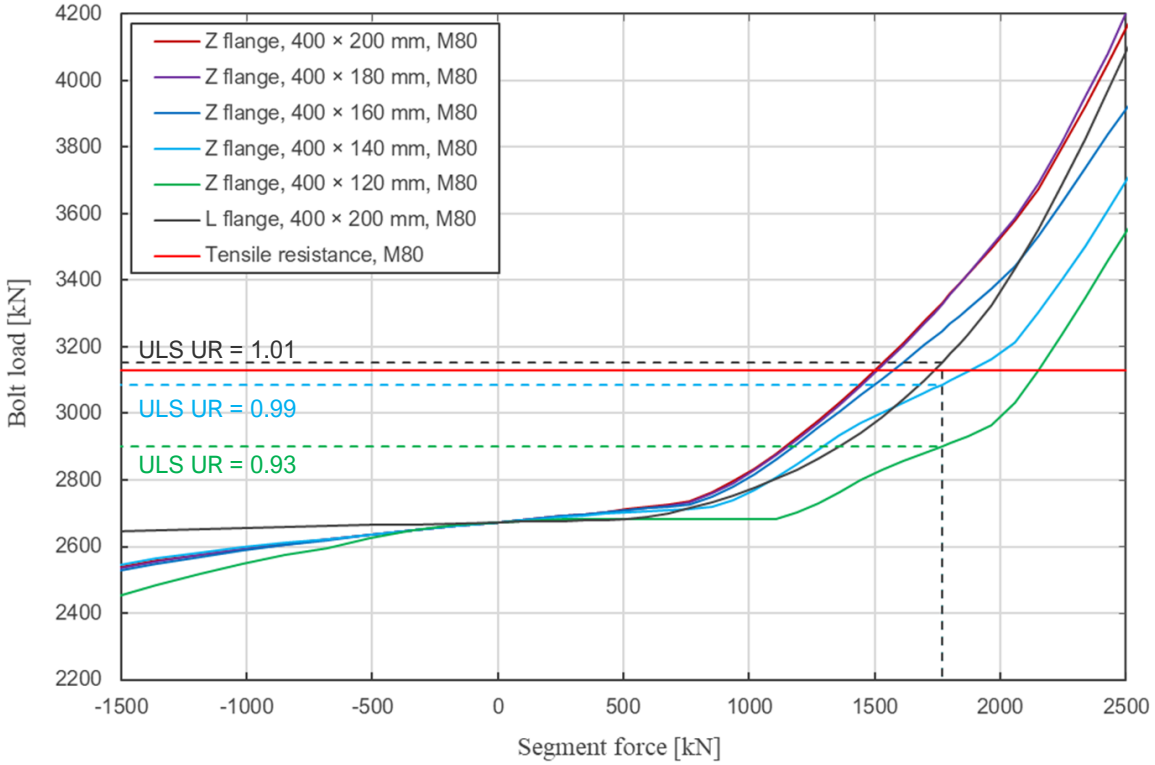
Analysis by FEA, capturing local flatness tolerance (waviness) and preloading





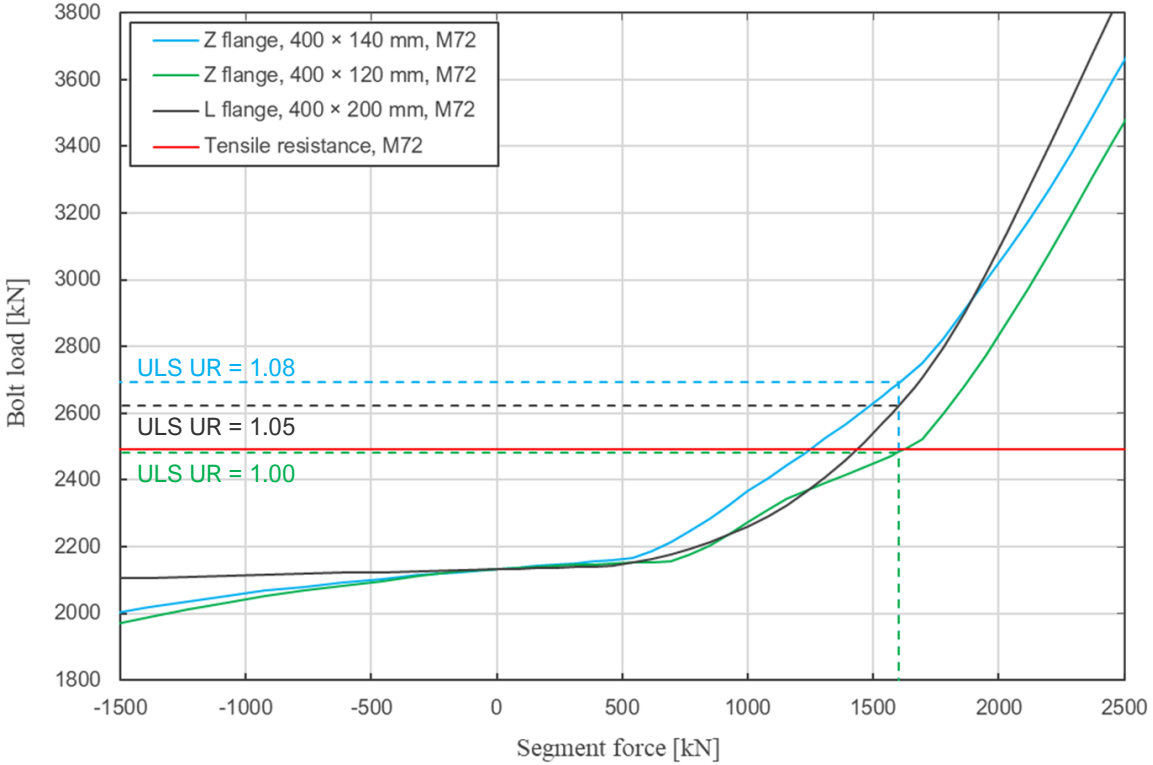
# HOW DOES IT PERFORM?

## Flange thickness




- L flange typically decreases in strength (ULS and FLS) with reducing thickness
- Z flange can flex with reducing thickness, increasing connection resistance to external loading

## Bolt size




- L flange typically decreases in strength (ULS and FLS) with reducing bolt size
- Z flange may provide a working design even with a reduced bolt size

# HOW IS IT BETTER THAN AN L-FLANGE OR ANY OF THE ALTERNATIVES?

## Design:

- **May give a working design where a tapered flange cannot**
- Better bolt performance and reduced gapping at the OD in response to external prying loading
- Reduced gapping at the OD in response to external prying loading
- Greater accommodation fabrication tolerances (flatness)

## Procurement, fabrication and installation:

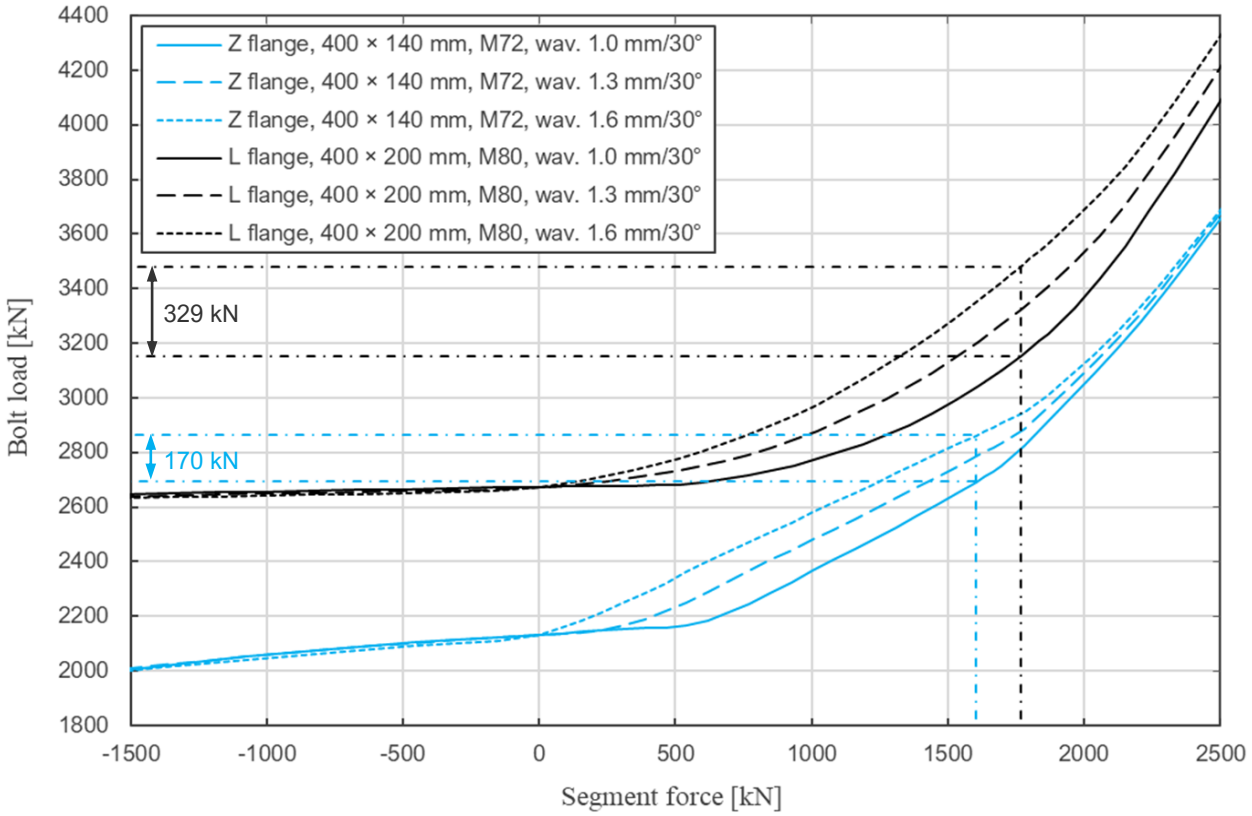
- **30 – 60% thinner than tapered flange**
- **Smaller bolt sizes may be possible**
- No increase in machining time vs. tapered flange
- No major change to bolt installation requirements for design (requires hydraulic tensioning)
- No different requirements for specification of bolts
- Certified for use on offshore wind project

# WHERE HAS IT BEEN USED?

## What level of development is it at? (patents etc.)

- Certified for use on offshore wind project
  - Currently on European construction project
- Installability validated by mock-up testing
  - Target preload range achievable
  - Flange flexure within design expectations
  - Elastic springback resists short-term preload loss
  - Tolerant of retightening
- Technology readiness level 5-6
- Patents pending in EPO (Europe) and US

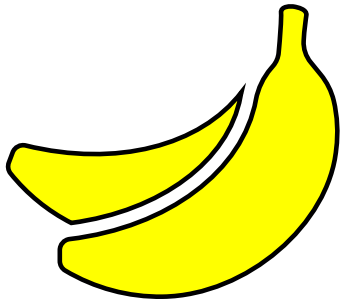
# ANY EFFECT FROM RECENT CODE CHANGES AROUND FLATNESS TOLERANCES?




- Z flange may demonstrate greater acceptance of fabrication tolerances, due to contact pressure distribution and flange flexure

# WHERE SHOULD WE USE IT?

- ✓ Where a tapered L-flange simply won't work
- ✓ Where a reduced bolt size is needed
- ✓ Where a reduction in steel is desired

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